VTT Technical Research Centre of Finland

Advancing Circular Business

Valkokari, Pasi; Tura, Nina; Ståhle, Matias; Hanski, Jyri; Ahola, Tuomas

Published: 24/01/2019

Document Version
Publisher's final version

ADVANCING CIRCULAR BUSINESS

Valkokari P., Tura, N., Ståhle, M., Hanski, J., Ahola, T.

From Data to Wisdom:
Approaches enabling circular economy

ADVANCING CIRCULAR BUSINESS

ISBN 978-952-15-4307-4 (printed)
978-952-15-4308-1 (PDF)

Layout by Manu Pärssinen / Alasin Media Oy
Printed and bound by Kirjapaino Hermes Oy, Tampere, Finland, 2019

CONTENTS

PREFACE

Climate change and the scarcity of natural resources affect everyone. These issues are the main reasons why discussions of circular economy (CE) as a means to promote sustainability have come to the fore in recent years. According to Sitra[1], CE has the potential to cut 56% of heavy industry's CO2 emissions in the EU by 2050. OECD[2] and European Parliament[3] have identified CE as an important means for increasing resource efficiency and reducing the use of natural resources. Additional reasons for adopting CE include environmental benefits from the reduced extraction, processing, and disposal of natural resources; reducing the reliance on critical material inputs to mitigate supply risks; and business opportunities in various sectors, such as services, sharing economy, remanufacturing, and secondary material production[2].

It is stated that digitalization can contribute significantly in transitioning to a more sustainable CE. It is also said that it could help to close the material loops by providing precise data on the availability, location, and condition of products. One claim is that digitalization could also allow for more efficient processes in business, help reduce surpluses, support longer life for goods, and diminish transaction costs. Thus, digitalization could boost the implementation of CE business models by helping to close, slow and narrow the material loop with increased resource efficiency.

However, how do digitalized solutions really affect businesses? Do they create new challenges for life cycle management? Does required new hardware contain harmful substances that must be managed after its first life? What about the increase in energy consumption for smart solutions? In other words, *How could digitalization really promote the implementation of CE strategies?*

The answer may lie behind the claim: digitalization could provide precise data on the availability, location, and condition of products when available proper competencies are available to transform the data into information, knowledge, or even wisdom in order to decide appropriate measures for beneficial CE business creation.

It is essential, then, to understand the importance of information management if one business actor is interested in implementing CE strategies. This is the justification for this publication; the main objective is to open—in addition to biological and technical cycles—the third necessary cycle of CE strategies. This third cycle includes the aspects related to data, information, knowledge, and wisdom.

The research and development project titled "From Data to Wisdom—Approaches Enabling Circular Economy" has sought new knowledge on how companies can systematically identify relevant data, create new value constellations, and then convert data into wisdom that is used to implement new circular operational and business models. The research work was conducted by VTT Technical Research Centre of Finland, Ltd., LUT University, and Tampere University.

1Sitra (2018). The circular economy—A powerful force for climate mitigation.
2 McCarthy, A., Dellink, R., and Bibas, R. (2018). The Macroeconomics of the Circular Economy Transition: A Critical Review of Modelling Approaches. OECD Environment Working Papers.
3 European Parliament (2018). Resource efficiency and circular economy. Fact Sheets on the European Union - 2018.

The authors wish to thank the Data to Wisdom companies—BMH Technology, Fortum, Solita, and UPM—and the steering group members Antti Brunni, Ville Hakanperä, Tero Junkkari, Helena Kortelainen, Miia Martinsuo, Ville Ojanen and Tuomas Paloviita for their active cooperation during the project. The project was funded by Business Finland's BioNets program and by participating organizations.

January 2019

Pasi Valkokari
Nina Tura
Matias Ståhle
Jyri Hanski
Tuomas Ahola

TIIVISTELMÄ

Maapallon resurssien huvetessa kiertotalous on tunnistettu tärkeäksi keinoksi resurssitehokkuuden lisäämisessä ja luonnonvarojen käytön vähentämisessä. Toisaalta ymmärrys mitä kiertotalouden operatiivisten ja liiketoimintamallien käyttöön ottaminen vaatii yritysten ajattelumalleilta ja mikä sen merkitys kilpailukyvylle on, eivät ole vielä laajalti konkretisoituneita asioita. Tässä julkaisussa esitellään käytännön esimerkkejä kiertotalouden eri liiketoimintojen toteutuksista. Tutkimuksen pääpaino on ollut tunnistaa informaatiohallinnan rooli menestyksekkäässä kiertotalouden liiketoiminnan toteutuksessa. Julkaisun tavoitteena on tarjota yritysedustajille käytännön tuloksia ja oppeja kiertotalouden operatiivisten- ja liiketoimintamallien toteuttamisesta.

Tämän julkaisun tavoitteena on viitoittaa polkua kiertotalouden liiketoiminnan suuntaan tarjoamalla:

1. kuvauksen mitä kiertotalous on
2. kuvaamalla kiertotalouden vaikutuksia liiketoiminnan toteuttamisessa
3. tarinoita informaation roolista kiertotalouden liiketoiminnan luomisessa
4. käytännön työkaluja kiertotalouden liiketoiminnan luomiseen

Julkaisun rakenne seuraa tätä logiikkaa ja esittelee käytännön esimerkkitapauksia kiertotalouden liiketoiminnan kentältä. Julkaisussa esiteltäviä työkaluja ja menetelmiä sovellettiin ja kehitettiin edelleen yritysyhteistyössä, johon osallistuivat BMH Technology, Fortum, Solita ja UPM.

Tämä julkaisu kokoaa projektin “Data to wisdom - Approaches Enabling Circular Economy” (D2W) keskeisimmät havainnot ja tulokset. Hanke alkoi elokuussa 2016 ja se kesti aina tammikuuhun 2019. Tutkimustyöhön osallistuivat VTT, LUT-yliopisto ja Tampereen yliopisto ja se toteutettiin osana Business Finlandin BioNets ohjelmaa.

D2W-projekti tarjosi hyvän yleiskuvan kiertotalouden liiketoiminnan kehittämisen vaatimuksiin monialaisen osaamisen kattavassa usean yrityksen projektissa. Projektissa keskityttiin tarkastelemaan kiertotalouden liiketoiminnan kehittämistä erityisesti kolmen eri näkökulman kautta, joita olivat innovaatiot ja liiketoimintamallit, verkostot ja yhteistyösuhteet, sekä tieto ja viisaus.

Koska D2W-projektissa lähestymistapa oli laaja, on joitakin ehdotettuja työkaluja ja menetelmiä syytä edelleen jalostaa, jotta ne olisivat entistä käyttökelpoisempia yritysten ja organisaatioiden hyödynnettäväksi. D2W-projektin työtä siis jatketaan ja uusien tutkimus- ja kehityshankkeiden valmistelu on käynnissä yhdessä toimijoiden kanssa, joiden mielenkiinnon kohteena on lisätä valmiuksiaan kiertotalouden periaatteita noudattavan liiketoiminnan luomisessa. Esimerkkejä uusista aiheista seuraavien vaiheiden tutkimukseen ovat muun muassa:

- Kiertotalouden ja kestävän kehityksen avainindikaattorit
- Kiertotalouden liiketoimintaekosysteemin ohjaaminen
- Tekoäly (IT teknologia), mahdollisuudet ja vaatimukset kiertotalouden liiketoiminnan implementoinnissa

EXECUTIVE SUMMARY

In this world of scarce resources, circular economy (CE) has been identified as an important means for increasing resource efficiency and reducing the use of natural resources. What, however, does implementing circular business and operational models mean for companies' business execution, mindsets, and competitive edges? This publication presents the practical case studies of several different CE business implementations. The focus on this exploration was to identify the role of information management in successful CE business implementation. The outcomes offer a chance for different representatives of different firms to learn from practical cases of CE implementation in operational and business models.

This publication aims to show the pathway toward CE by providing

1. a description of CE
2. an explanation of its impact on business execution
3. stories about the role of information in the creation of CE business
4. practical tools for the creation of CE business

The structure of the publication tracks similar logic to, and presents practical case examples from, the field of CE business. Tools and methods were applied and further developed within the case companies: BMH Technology, Fortum, Solita, and UPM.

The publication presents the major results of research and development work performed within the "From Data to Wisdom—Approaches Enabling Circular Economy" project (D2W). The project was initiated in August 2016 and continued until January 2019. The research work was conducted by VTT, LUT University, and Tampere University as part of the BioNets program of Business Finland.

The project provided a good overview of the demands of CE business in a multidisciplinary multi-company setting. It focused on three approaches for examining circular business: innovation and business models, relationships and networks, and data and wisdom.

Since D2W had a broad scope, some of these approaches should be developed further to provide practical tools for business developers (companies and organizations). The work of D2W will therefore continue. Case-specific projects are being considered to develop practical results for the needs of practitioners interested in improving their capabilities for CE business creation. Examples of new topics for the subsequent steps of research include, for example:

- Key performance indicators of CE and sustainable development
- Governance of CE business ecosystems
- New artificial intelligence (AI) technologies, opportunities and requirements in CE business implementation

1 EMERGENCE OF CIRCULAR ECONOMY

Circular economy is predicted to grow in importance as a way of maximizing profits in the future. Moving from linear operations to circular value creation is revolutionizing various industries across the world. Companies have increasingly started to look for sources for added value creation through services and smart approaches (intelligence-based digital solutions)—for example, by paying attention to maintenance and reusing and remanufacturing activities. In Finland, CE business is particularly driven by the Finnish Innovation Fund Sitra, whose work has gained worldwide recognition. Sitra has, for example, listed inspiring examples of Finnish companies that have changed their operations and revenue models to drive CE. In addition, Sitra has established the world's first roadmap to CE: "Leading the Cycle—Finnish Roadmap to a Circular Economy 2016–2025." The aim of the roadmap is to guide Finnish companies in finding new ways to increase added value creation and to lead Finland as a CE pioneer.

Despite the good intents and increasing interest, the transition from a traditional linear business to a circular one is not easy. The aim of this publication is to provide information about CE and circular business by shedding light on promising case examples from Finland. More importantly, this publication discusses the role of information in circular value creation. It also provides a toolkit with research-based resources for managers to use on their road toward circular business.

1.1 What is Circular Economy?

CE is an economic system that is restorative by intention and design and where the resource and energy flows are to be closed, narrowed, and slowed down[1]. In other words, a CE system is about creating value from waste by capturing and reusing finite materials and energy[2]. CE has been described as responding to calls for sustainability[3] and solving the challenges of traditional linear "end-of-life" logic where competition and supply risks of scarce resources have increased[4]. CE has become increasingly concerned not only with environmental impacts but with economic benefits. From a business perspective, we may talk about circular business as referring to solutions and business models that aim at enhancing CE, responding to minimizing environmental impacts, and creating short- and long-term economic benefits. Traditionally, the CE model distinguishes between biological (consumption) and technical (the recovery of materials and products) cycles, as seen in Figure 1.

1 Ellen MacArthur Foundation (2013). Towards the Circular Economy: Economic and business rationale for accelerated transition.
2 Kraaijenhagen et al. (2016). Circular Business: Collaborate & Circulate.
3 Murray et al. (2015). The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context
4 Lieder and Rashid. (2016). Towards circular economy implementation: a comprehensive review in context of manufacturing industry. Ghisellini et al. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems.

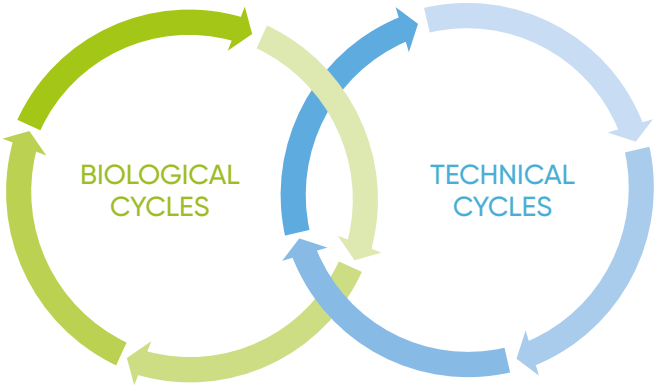


Figure 1
BIOLOGICAL AND TECHNICAL CYCLES OF CIRCULAR ECONOMY.

Biological cycles consider food and biologically based materials (such as wood and cotton) and their circulation back into the consumption system through, for example, composting. Biological cycles provide renewable resources as they regenerate living systems (e.g., soil).

Technical cycles consider the products, materials, and components, as well as their recovery and restoration. The strategies used include principles of reuse, repair, recycling and remanufacturing.

1.2 How is Circular Economy Revolutionizing Industries?

CE has the potential to revolutionize many industries as companies begin to develop their business models around the ideas of extending product life cycles, expanding from products to services, and focusing on renewability and resource efficiency. Building on the definition of CE, several authors have provided categories for CE business models[1]. Perhaps the most well-known categorization is by Bocken et al. (2016)—that of **slowing resource loops** through design for long-life goods and extending product life, **closing resource loops** through recycling, extending resource value and industrial symbiosis, and **resource efficiency or narrowing resource flows** by using fewer resources per product. Using a more business-oriented approach, Sitra (2017) and Lacy and Rutqvist (2015) present a complementary categorization of CE business models. In this publication, the types of circular business are considered through this categorization of business models:

1. product life extension;
2. product as a service;
3. sharing platform;
4. renewability; and
5. resource efficiency and recycling.

1 Lacy and Rutqvist (2015). Waste to Wealth: The Circular Economy Advantage. Bocken et al. (2016). Product design and business model strategies for a circular economy.
Sitra (2017). The most interesting companies in the circular economy in Finland. Ellen MacArthur Foundation (2013). Towards the Circular Economy: Economic and business rationale for accelerated transition.

In Finland, the development of circular business is a highly strategic issue. The growth is especially linked to the use of material flows across industries, creating value with the design and brand, expanding from products to services, and generating value through platforms[2]. Many industries in Finland have started to look for new business models based on these ideologies. The graphics below address the development of circular business from the perspectives of four industries: forest, waste management, energy, and information technology (IT). In the graphics, the case companies and business model types addressed in this publication are introduced through examples from these organizations. It must be noted that case companies and examples could be also linked to other business model types.

2 *Ek (2016). Take a leap into circular economy.*

PRODUCT LIFE EXTENSION

Product life extension aims at increasing the value from invested resources, providing a useful life that is as long as possible, and maximizing profitability over the life cycle of assets. It includes activities such as repair, upgrade, and remanufacture.

Life cycle thinking is one of the core ideas in CE. The aim to enhance efficiency has already driven many industries to pay attention to maintenance and asset management operations. The aim is to keep products and equipment usable as long as possible through maintenance and refurbishment activities.

UPM: Equipment reuse

UPM is a large global company operating in bio and forest industry. Its main products are biofuels, biocomposites, biochemicals, paper, pulp, plywood, and energy. Life cycle thinking is a crucial part of the company's operations. UPM seeks operating efficiency from effective maintenance and asset management. Reusing assets from closed production lines is a prime example of extending product life cycle.

PRODUCT AS A SERVICE

Product as a service covers business models where the manufacturer or brand owner retains the ownership of an asset and offers it to customers as a service. In this business model, the company offering the product has an incentive to optimize the use and life cycle of the asset.

Companies in many industries have started to look for ways to expand from products to service business and toward life cycle thinking. Businesses based on manufacturing and selling products have been expanded to cover new service concepts (e.g., based on maintenance and waste management). Examples include leasing, refurbishment, and maintenance (i.e., increasing the value of products). Digital services and IoT also provide new means for value creation.

BMH Technology: SRF as a service

BMH Technology is a medium-sized firm operating globally and offering its customers fuel production plants and waste management systems. The company has a waste management solutions unit that offers its customers solutions for refining community and industrial waste into solid recovered fuel (SRF) that can be combusted in power plants. Different services, such as spare parts, life cycle maintenance, and modernization, are also offered. BMH Technology is increasingly expanding its services portfolio to include progressively different life cycle and operations services for its global customer base. Therefore, its vision is to move from a system delivery company toward a service-oriented partner to its customers.

SHARING PLATFORM

A sharing platform provides a means to connect asset owners with individuals or companies interested in using them to boost asset productivity.

The IT industry plays a remarkable role in enabling other industries to create CE business. The goal of sharing platforms is to help companies expand their operations across market boundaries, use external resources, share information, and increase collaboration. In a B2B context, sharing platforms allow, for example, the establishment of new types of business based on information sharing and better use of by-products or the facilitation of collaboratively owned equipment.

Solita: Amer Sports platform solution

Solita is a medium-sized digital business consultancy that serves customers in both public and private sectors. Solita supports its customers through service design, enterprise architecture, custom software, eCommerce, analytics, data science, business intelligence, IoT, integrations, and cloud services. From the CE point of view, Solita develops and delivers sharing economy-based solutions that increase the resource effectiveness of its customers' business processes. Amer Sports focuses on sporting goods and outdoor markets. It is a truly global company that operates in the consumer business. The sharing platform developed by Solita and Amer Sports is an example of using sharing platforms to enhance the sustainability and CE of consumer markets.

RENEWABILITY

In a **renewability** business model, renewable, recyclable, or biodegradable materials, components, or products are used as substitutes for linear ones.

Sustainable development in general and CE in particular are driven by the need to replace existing non-renewable materials used in production. Many companies have started to look for solutions to use renewable and biodegradable components in product design as well as in eco-design. This also includes efforts to replace fossil fuels with renewable energy sources. Forest and energy industries have in particular have expanded their operations in this direction.

UPM: Renewable diesel

In 2015, UPM started its operations of producing wood-based renewable diesel UPM Bio-Vern. The product aims to replace the fossil fuels used for transportation with a sustainable fuel, thus enhancing sustainability. The product is produced from crude tall oil, the side streams of pulp production processes. Compared with fossil fuels, renewable diesel reduces greenhouse gas emissions and cuts down on the use of limited non-renewable resources. In comparison with traditional biofuels, UPM renewable diesel uses non-edible materials as raw materials, increasing the sustainability of operations.

RESOURCE EFFICIENCY AND RECYCLING

The aim of **resource efficiency and recycling i**s finding value in all material streams by discovering resources hiding in organizations' production outputs and discarded assets.

Partnerships and collaboration are a driving force in CE. The industry boundaries are fading, and new models are built in cross-sectoral group efforts based on the idea of using material flows across the sectors. In addition, many companies have started to collect old (and waste) materials and use them to create new products. For example, the global goal of replacing and recycling plastics is driving companies to seek innovations.

Fortum: eNext and HorsePower

Fortum is a large energy company offering its customers clean-energy solutions, including electricity, heating, cooling, and smart solutions to improve resource efficiency. One of Fortum's divisions is City Solutions, under which there are different business units. These include, for example, eNext and Recycling and Waste Solutions. eNext focuses on providing expert services related to district heating and cooling, the energy recovery of waste, biofuels, and other recycling solutions. The solutions are provided in a sustainable manner (e.g., by using industrial surplus heat). In 2015, Fortum expanded its operations to more closely reflect CE by establishing HorsePower as part of Recycling and Waste solutions. In Horse Power, the business is based on the idea of using material flows across the sectors, including forest, farming, and energy industries.

1.3 What is the Role of Information in Circular Business?

The use of data and IT has the potential to change the way value is created and to enable better resource efficiency for societies[1]. Many CE solutions are supported or even enabled by data and digital platforms. They ensure the availability, reliability, and transparency of the solutions to the relevant actors and stakeholders.

It is essential, therefore, to understand the importance of information management if a firm is interested in implementing CE strategies and solutions. Thus, this publication introduces the third necessary cycle of the CE: **the information cycle** (see Figure 2). The information cycle includes the aspects related to data, information, knowledge, and wisdom.

The data, information, knowledge, and wisdom hierarchy (DIKW) [2] is a useful representation of different stages of information cycles. Data covers the values and observations from selected variables, such as measured value by a technical sensor. When data is transformed to a meaningful and useful form, it becomes information. An example of information is a trend of failure rate. Knowledge is the ability to interpret trends and to recognize when there is a need for action. A professional skill of understanding information that has developed over a long time is an example of knowledge. Wisdom is the ability to understand relevant alternative actions in the current situation, to compare them, and to make an optimal decision supported by appropriate decision support tools.[3]

It is crucial to understand the stage of DIKW hierarchy needed to develop and implement a CE solution. For example, if only a database of measurements is required, the data stage is sufficient. However, if there is a need to visualize the results or to understand when measurements deviate from the norm, there is a need for the information or knowledge stages. In many cases, the information level is sufficient to manage even a complex CE solution. Examples of the role of information in CE solutions are presented in the following case studies. The case studies do not consider whether the firms are capable of using this information as organizational knowledge or wisdom in decision-making.

1 EMF (2016). Intelligent assets: unlocking the circular economy potential.
2 Ackoff (1989). From data to wisdom.
3 The explanation of the different stages of the hierarchy is based on the ideas of Kunttu et al. (2016).

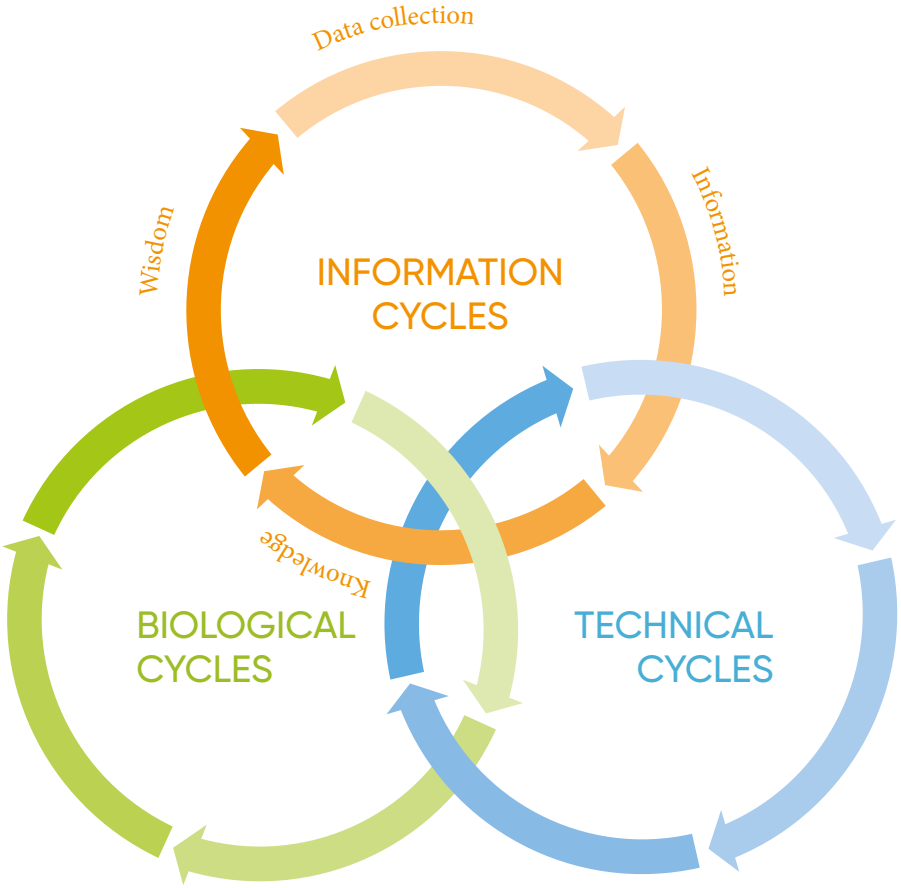
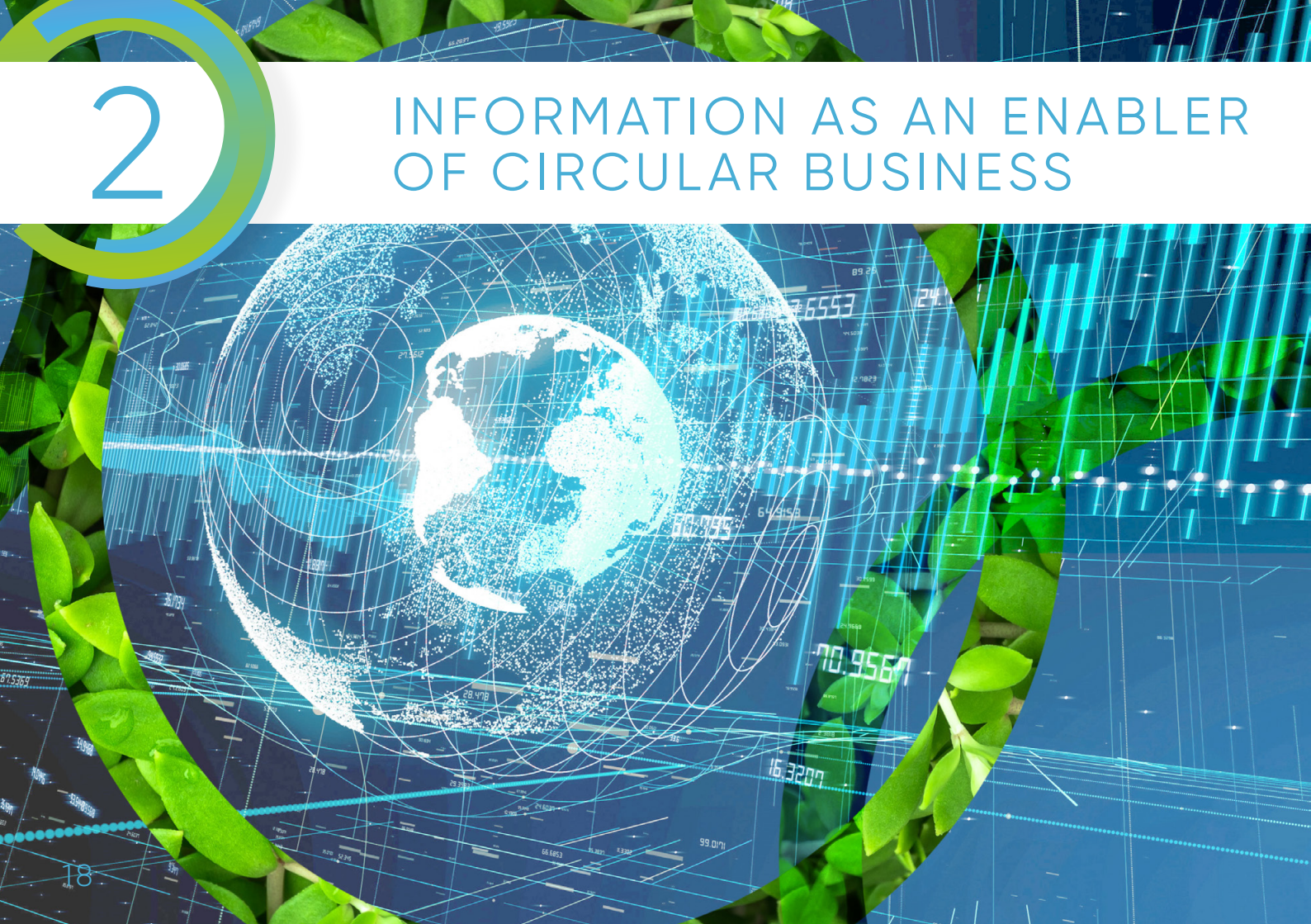


Figure 2
INFORMATION AS A THIRD DIMENSION OF CIRCULAR ECONOMY.

2 INFORMATION AS AN ENABLER OF CIRCULAR BUSINESS



Information is a key enabler for circular business. To help in better understanding the role of information in circular business, this chapter illustrates the information needs and flows between different stakeholders through four business cases analyzed in the D2W project. These cases include UPM's equipment reuse, BMH Technology's SRF as a service, Solita's Amer Sports platform solution, and Fortum's HorsePower. Following a brief description of the business concept and its underlying motivation, each actor involved in value creation is introduced and the discussion is focused, in particular, on the role of information in fulfilling the actor's business need. The presented figures (3–6) illustrate the material and information flows through the actors involved in these concepts. Section 2.5 concludes the key findings across the cases.

2.1 UPM: Refurbishment and Reuse of Equipment and Components (Life Extension)

Motivation

- Due to reduced demand and overcapacity in some areas of the paper industry, paper companies have closed production lines and facilities. Closing of production lines and the strategic shift toward CE has sparked UPM's concept of reuse.
- Equipment in the pulp and paper industry holds considerable value, and reuse activity is profitable from a financial point of view. In addition to the clear benefits of cutting costs, the closed production lines provide spare parts that are not necessarily available from anywhere else (a lack of spare parts would force considerable investments in new equipment).
- The main challenges in the reuse concept include resources required for analyzing the criticality and demand for equipment, quality of information, and specificity of equipment for a certain use case.

Business concept

- The equipment and components are reused as a part of new investments, reused as spare parts in existing facilities, or sold outside the company. Equipment and components that are considered important but currently have no demand are refurbished and stored.
- Information plays a crucial role in the concept. The main equipment-specific information from closed production lines is stored in a database. Users of the database can make reservations for the equipment and components.

Conclusion

UPM's case depends on the availability of information for the equipment and components from production lines that are at the end of their life cycle. The solution requires an information platform. In addition, there must be a connection to potential internal and external customers. To increase efficiency and reduce delays and storage, information about, e.g., investment plans of both external and internal customers are needed. The solution depends on the expertise of evaluating which equipment and components could be reused, by which internal or external customers, and in which operating environments.

KEY ACTORS			
UPM's reuse function	**UPM's maintenance department**	**Client (internal or external)**	**Logistic service partners**
ACTIVITY			
Sorting	Collect, refurbish, and store equipment and components	Reusing or purchasing refurbished equipment or component from EOL production line; Materials recycling	Reverse and delivery logistics: Sorting
MOTIVATION			
Economic benefits, strategic focus on CE at corporate level	Support cost-efficiency of the company	Cost-efficiency by extending life cycle/ using less-expensive equipment/ components, brand lifting; Economic benefits, strategic focus on CE at corporate level	Earning, employment
INFORMATION NEEDS			
Equipment demand and criticality	Basic equipment- and components-related criticality information	Spare part availability information, material type, and quantity; Logistics-related data such as weight, size, characteristics of delivery, collection/delivery time and destination	Logistics-related data such as weight, size, characteristics of delivery, collection/delivery time and destination
INFORMATION PRODUCED			
Reusability of equipment and components	Spare part availability information	Information related to operational performance for continuous improvement	Location of delivery, estimate of delivery time

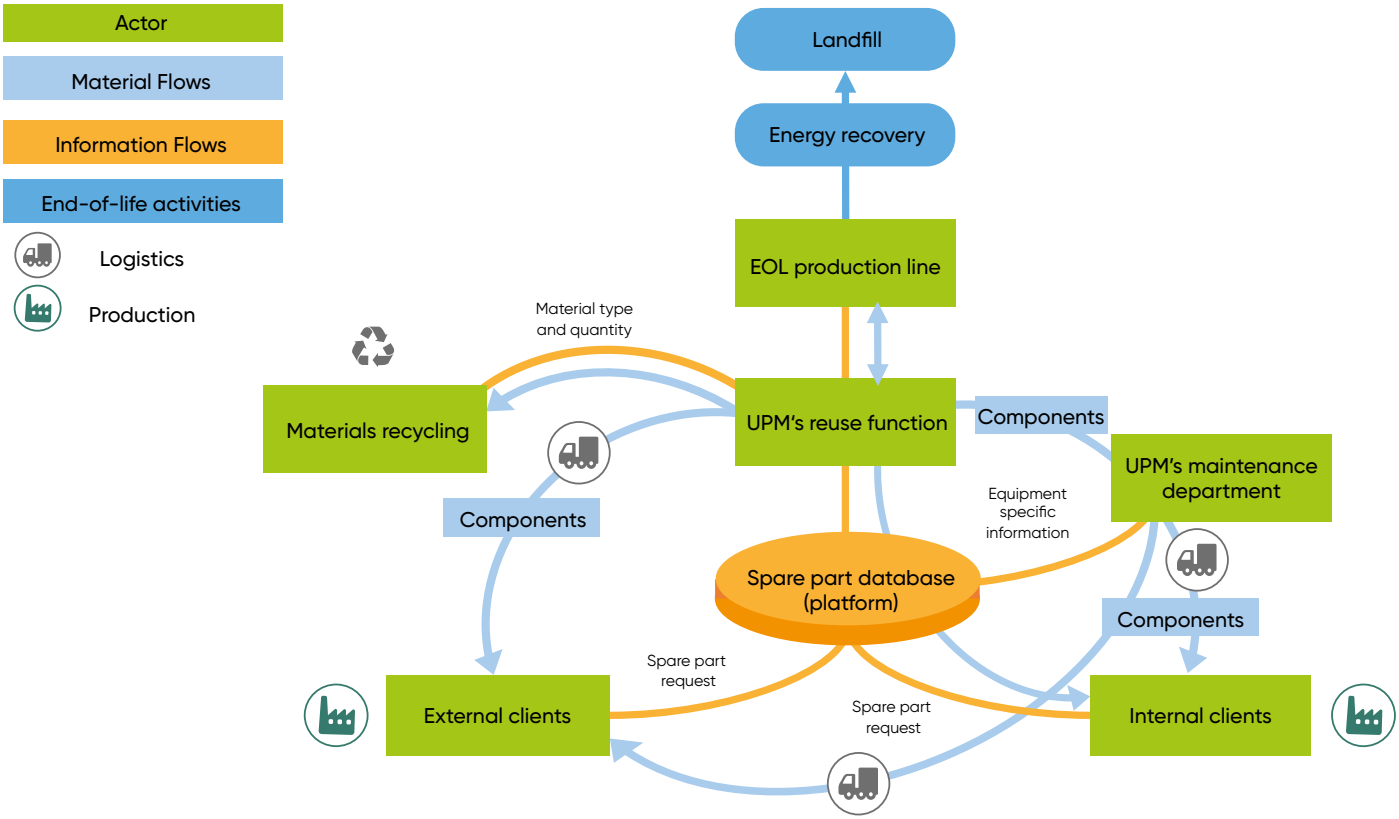


Figure 3
INFORMATION AND MATERIAL FLOWS IN UPM'S CASE CONTEXT.

2.2 BMH: Solid Recovered Fuel as a Service (From Products to Services)

Motivation

- Global motivation to shut down and get rid of landfills
- Increased need to recycle useful materials
- BMH's motivation is to develop its service business and increase the stability of its overall business.
- Power plants would like to concentrate on their core business (i.e., operating the power plant).

Business concept

- All useful materials are recycled and the rest of the waste (mainly plastics) is shredded, resulting in solid recovered fuel (SRF) that can be combusted in the power plants' boilers.
- BMH gets, e.g., a monthly fee from delivering the SRF to power plants → SRF as a service.
- Business model is based on the selling capacity of the SRF production plant.
- BMH provides the steady flow of fuel for the power plants by operating the SRF production systems.
- Power plants combust the SRF and produce heat and electricity for society.
- Business model is currently at a conceptual level.

Conclusion

As shown in Figure 4, most of the information and material flows form cycles throughout the system. In this case, BMH acts as a central information node where the information flows about end users, waste management companies, and power plants are crossing. The role of information in this business model is crucial since the needs and requirements of each actor in the network need to be identified. In addition, information about the composition of waste is very important, as the SRF production systems need to be optimized based on this information. This also affects the quality of the service (SRF as a service) to be delivered to the customers. Detailed information is also needed regarding the valuable recyclable that are separated from the waste for use elsewhere. Furthermore, the waste management companies need detailed and correct information about logistics (e.g., delivery and collection times and locations) to deliver the waste and SRF to the right places at the right times. Since the business model itself is new in this type of industry, the idea and information about the model must be communicated clearly to potential customers.

KEY ACTORS			
BMH	**Power plants**	**Waste management companies/ Logistics partners**	**End users (e.g., cities and municipalities)**
ACTIVITY			
Delivering waste processing systems Operating the systems/SRF production plants Delivering steady flow and high quality of SRF	Producing heat and electricity for society from SRF Delivering energy to end users	Collecting the waste from cities and municipalities Delivering the waste to SRF production plants Delivering the sorted materials to external users (recyclers)	Use of energy and heat Recycling the waste
MOTIVATION			
More continuous and steady income flow from monthly fees Expanding service business Cumulative learning of the installed systems (utilization of the information in new deliveries and R&D)	Concentration on the core business (operating the power plant) Receiving stable flow of SRF/ energy source	Offering collection and delivery services to other parties	"Green image" when using waste as an energy source
INFORMATION NEEDS			
Potential customers Capacity of the systems needed Composition of the waste delivered by waste management companies	Quality/delivery of the SRF Quality of the process Price of the service or the fuel Maintenance breaks	Collection places and time of collection Locations of customers Quality and composition of the waste and SRF	Energy price
INFORMATION PRODUCED			
Price of the service SRF production rate Quality of the fuel Needed maintenance Deviations in production	Amount of fuel needed Capacity of the system Technical details regarding the energy production Energy price	Amount of waste to be delivered Time of the delivery Content of the waste Price of the delivery service	Amount of used energy and heat Energy consumption needs and preferences (time, amount, etc.)

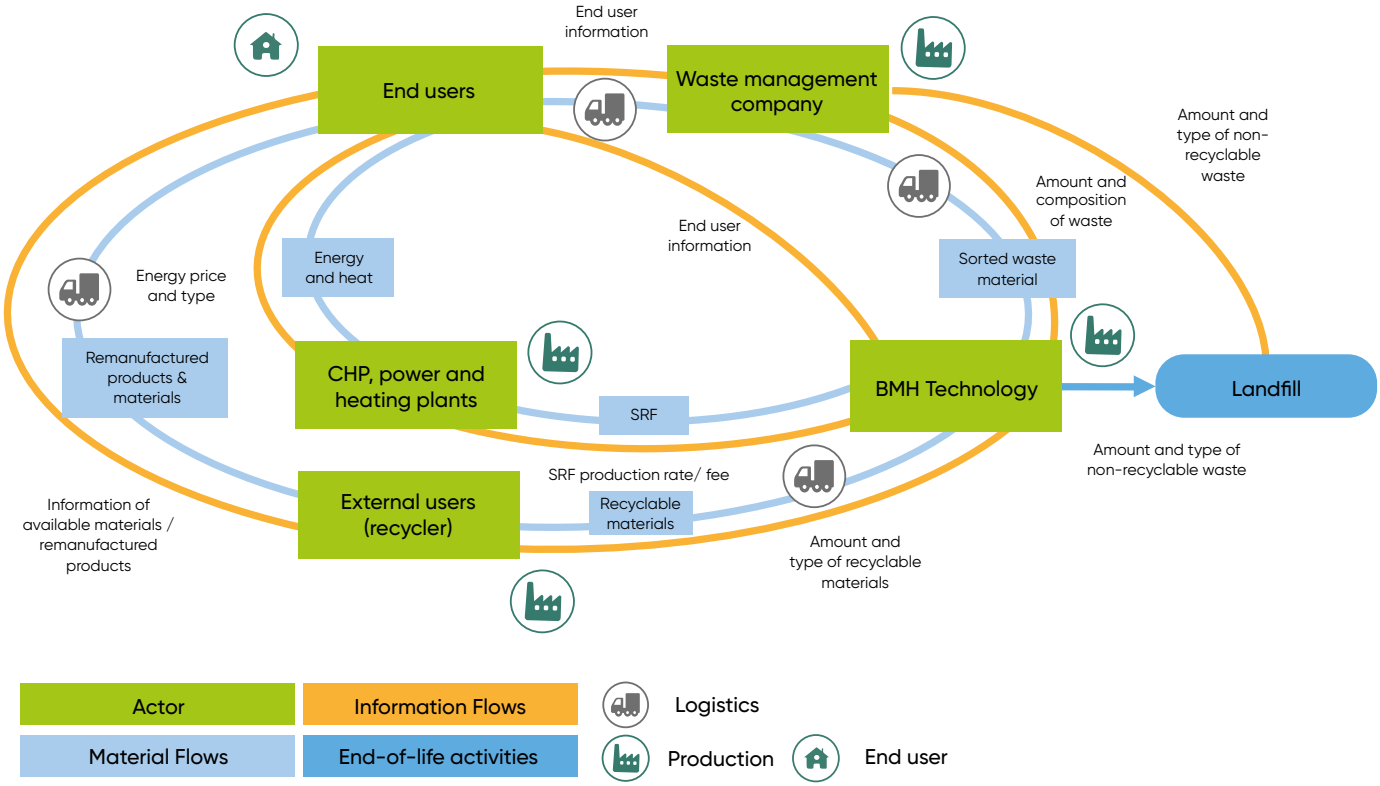


Figure 4
INFORMATION AND MATERIAL FLOWS IN BMH SRF AS A SERVICE CASE.

2.3 SOLITA: Amer Sports Information Platform (Resource Efficiency, Sharing Platform Variant)

Motivation

- Traditionally, Amer Sports has focused on how many products can be sold to retailers. The company possesses a lot of data in its network (ERP, CRM, and sport watches). This information is used to connect the data from production and sales activities.
- The goal of the information platform solution was to increase the transparency of the sales processes.
- The company can give its retailers forecasts on the sales of its products to avoid product and material losses.
- At the moment, the operating model is linear; however, during the production and storage stages, the solution promoted the principles of CE by reducing product, material, and energy losses.

Business concept

- Information platform connects production, sales, retailers, and users of the product.
- Provides accurate and detailed real-time sales forecasts to the actors that need the information
- Increased transparency and predictability translate into an optimized number of products to be manufactured, thus decreasing material costs and waste.
- Additional benefits include reduced storage costs, avoiding sales lost due to unavailability of products and costs related to preparation of sales forecasts. Total benefits were several million € in 2017.
- Accuracy of forecasts for new products was 91.4 % in 2017.

Conclusion

Information plays a central role in the Solita Amer Sports information platform. The improved material and energy efficiency is achieved by collecting data from end users, analyzing the data, and refining it into valuable information about the demand of specific products in specific geographical areas. The information is then transmitted to Amer's design and realization, Amer's sales, and the products' retailers. The success of this solution depends the on quality of the data, the accuracy of the analytics, combining information from different sources, and sharing the information to the relevant partners in the value network.

KEY ACTORS			
Amer Sports design and realization	**Amer Sports sales**	**Retailers**	**Users**
ACTIVITY			
Production	Selling the product to retailers	Selling the product to retailers	Activating the product (sales signal to the information platform)
MOTIVATION			
Reducing material and energy costs, meeting production targets	Sales	Reducing storage and waste-related costs, sales	Using the product
INFORMATION NEEDS			
Demand forecasts	Demand forecast, availability of products	Demand forecasts, customer needs, availability of products	Product-specific information
INFORMATION PRODUCED			
Availability of products	-	-	Type, timing, characteristics of activated product

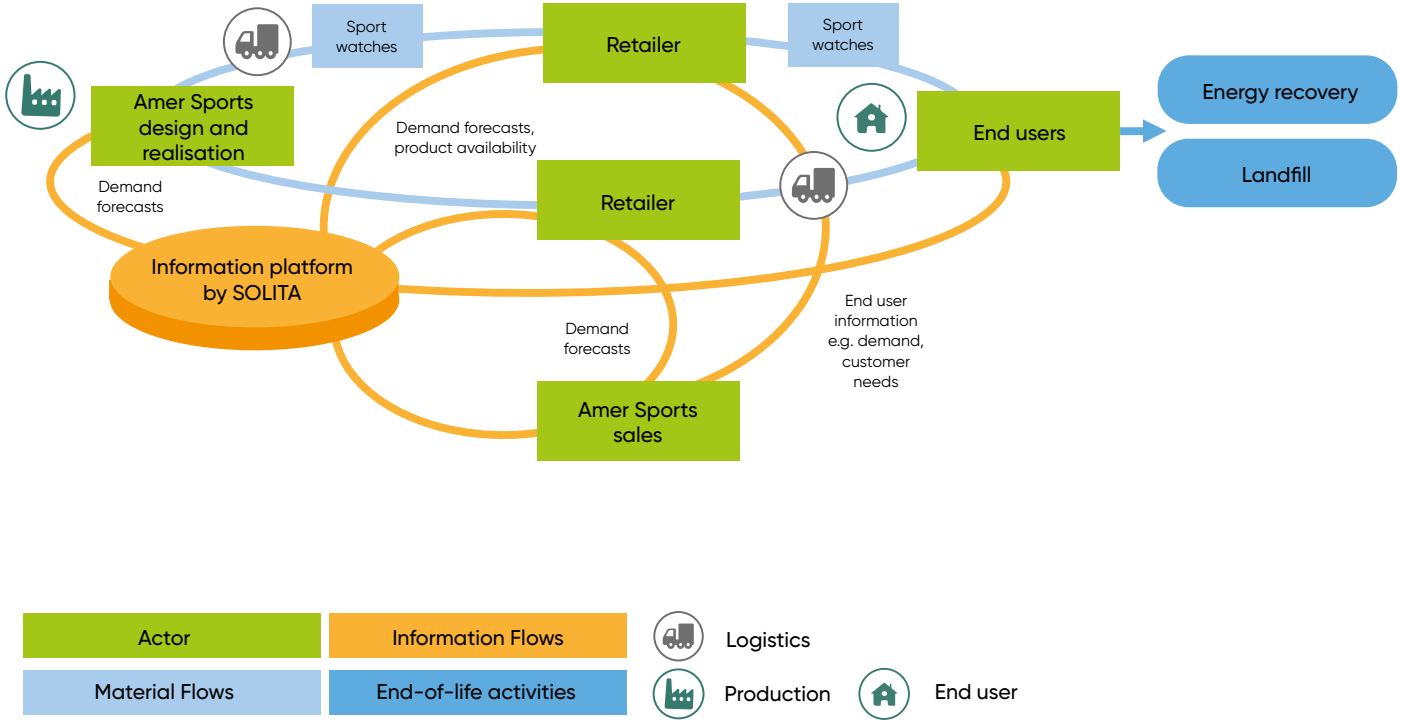


Figure 5
INFORMATION AND MATERIAL FLOWS IN SOLITA AND AMER SPORTS CASE CONTEXT.

2.4 FORTUM: HorsePower (Utilizing Material Flows Across Industries)

Motivation

- Huge problem & possibility: There are 6 million horses in Europe, each producing manure up to 10t/a. (Finland ~ 8,000 horses, Sweden ~ 400,000, Germany or France ~ 1 million etc.) Options to use or dispose of manure are costly and very limited. Horse manure is a problem waste. It is not allowed in landfills and has limited suitability, e.g., as fertilizer. Stables have limited possibilities to use manure themselves.
- Aim is to solve the problems of stalls, provide alternative for non-sustainable energy sources such as coal and for costly biomaterials, create profitable business based on services, and change the mindsets of decision-makers internationally.
- Possibility for creation of positive environmental impact (Co_2 reduction ca. 200kg/ton manure) and image benefits, localized energy production (no extra emissions, etc. from logistics)
- Fortum is committed to sustainable development and attempts to create new business that drives CE.

Business concept

- The business was established in 2015. It is currently operating in Finland (260 stables and around 8 power plants) and is starting in Sweden.
- The concept: 1) By-products from the forest industry are delivered for stables to use as bedding material. 2) Used bedding material and manure are picked up regularly (no need for long-time storage in the stable). 3) The manure is delivered to the power or heating plant. 4) Electricity and heat are used by end users. 5) Combustion ash is used (e.g., in civil engineering and as forest fertilizer).

Conclusion

As shown in Figure 6, most of the information flows through the Fortum HorsePower business unit. This unit works as an information platform, holding and transferring business information (such as material details and logistics information). The role of information in this business model is crucial. For example, the detailed and correct information about logistics (e.g., delivery and collection times and locations) is needed to optimize the complex logistic puzzle involving multiple actors (e.g., stables and logistic service partners). This is required to keep costs in control and enable competitive prices. Furthermore, as the service is highly dependent on both the power and heating plant's need for biofuel (manure-bedding material mixture) and the stable's need for the service, assessing the information about requiring these needs is a necessity. Thus, the solution requires professional skills to understand this information and the ability to turn this information into possibilities and concrete actions.

KEY ACTORS					
Fortum HorsePower	**Supplier (forest industry)**	**Client (stable)**	**Client (power plants, energy producers) (internal or external)**	**Logistic service partners**	**End user (heat and electricity users)**
ACTIVITY					
Waste management service for stables; selling of biofuel for power plants	Selling of by-products	Purchasing a service for waste (manure) management and bedding material delivery	Purchasing horse manure as a biofuel, and a service for fuel material delivery	Reverse logistics, delivery logistics	Use of energy and heat
MOTIVATION					
Economic benefits (revenue), strategic focus on CE at corporate level	Additional revenues from selling by-products	Better bedding material (health benefits), getting rid of manure	Cost-efficient bio-based fuel material Sustainability-related image benefits	Earning, employment	Overall reliability of energy and heat supply "Green image"
INFORMATION NEEDS					
Location and form of stables, power and heat plants and places of storage (logistics) Prices in energy markets Regulations and permits	Volume and type of requested by-product material Pick-up times (logistic operators)	Availability of bedding material Reliability of the material delivery and pick-up Price of the service	The amount and exact composition of delivered manure (e.g., the moisture percentage) Regulations and permits	Logistics-related data such as weight, size, characteristics of delivery, collection/ delivery time and destination The content of the service contract related to the loading of manure	Energy price
INFORMATION PRODUCED					
Amount and type of customers and their location Logistic requirements Profitability information	Type and amount of available materials	Information related to operational performance for continuous improvement	The amount and composition of environmental impacts of operations Operational requirements	Location of delivery, estimate of delivery time	Amount of used energy and heat Energy consumption needs and preferences (time, amount, etc.)

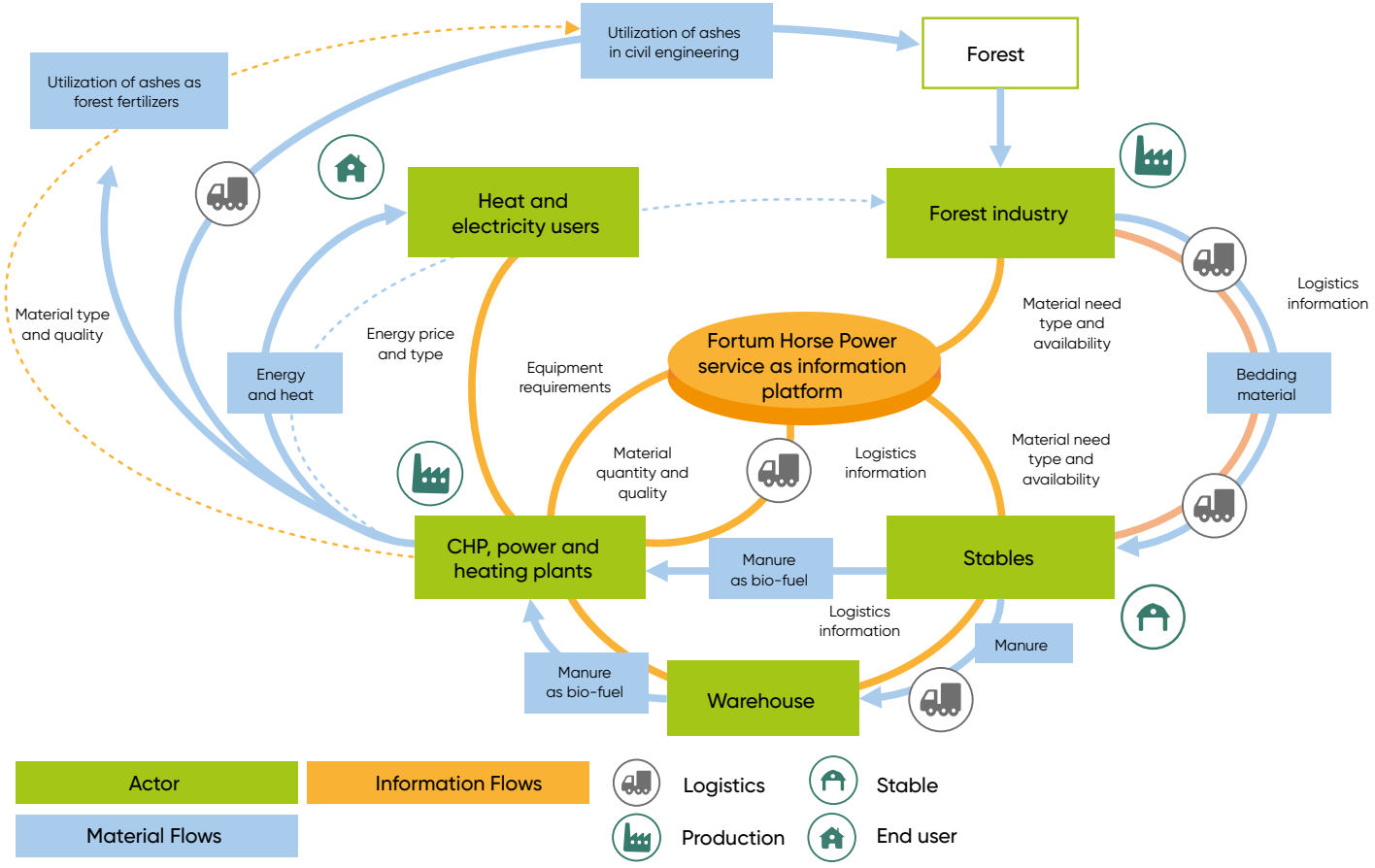


Figure 6 *INFORMATION AND MATERIAL FLOWS IN FORTUM HORSEPOWER CASE CONTEXT.*

2.5 The Role of Information in Circular Business Cases

We have illustrated the role of information in four CE solutions. Although the cases present different types of CE business models, the role of information in each is substantial. UPM's *refurbishment and reuse* of *equipment* and *components* is an example of a business model based on the idea of life extension. In this case, the information required includes the condition and characteristics of equipment and components that could be reused by other plants inside the company or sold to external clients and the needs of potential internal and external clients. An information platform is crucial for the management of the vast list of reusable equipment and components. *BMH's solid recovered fuel* as a service is an example of a business model focused on moving from products to services. In this case, the information cycle means collecting different types of information from different stakeholders so that the special service can be developed and communicated to customers and valuable materials can be used effectively. *Solita's Amer Sports information platform* relies on the idea of improving resource efficiency through a sharing platform. In this case, the entire business is based on the establishment of an information technology-based platform that collects data, analyzes it, and produces accurate predictions for the value network, including design and realization, sales, and retailers. Finally, Fortum's HorsePower is a business model based on the idea of using material flows across industries. In this case, both information and material flow across industries. Enabling the use of horse manure as a biofuel requires the skills and abilities to collect and analyze information from different stakeholders and combine these information pieces into knowledge to be used in decision-making and business optimization.

The following matrix (Figure 7) can be used for categorizing CE solutions and identifying potential similarities among business concepts. In particular, solutions studied in the D2W project were found to differ regarding two key characteristics: how they leveraged information and whether they resulted in the establishment of new material cycles. Our findings show that solutions can either be centered on information concerning the production process or rely primarily on information describing the status or condition of the production equipment itself. Additionally, solutions may focus either on improving the efficiency of existing product or material cycles or discovering and leveraging entirely new cycles.

In each of the case studies presented, research and development work were also involved. During this work, several approaches were explored according to case-specific objectives. To facilitate the development and piloting of CE initiatives in companies, concrete tools are needed to implement potential CE business ideas. The following chapter discusses the tools used and tailored for promoting CE business.

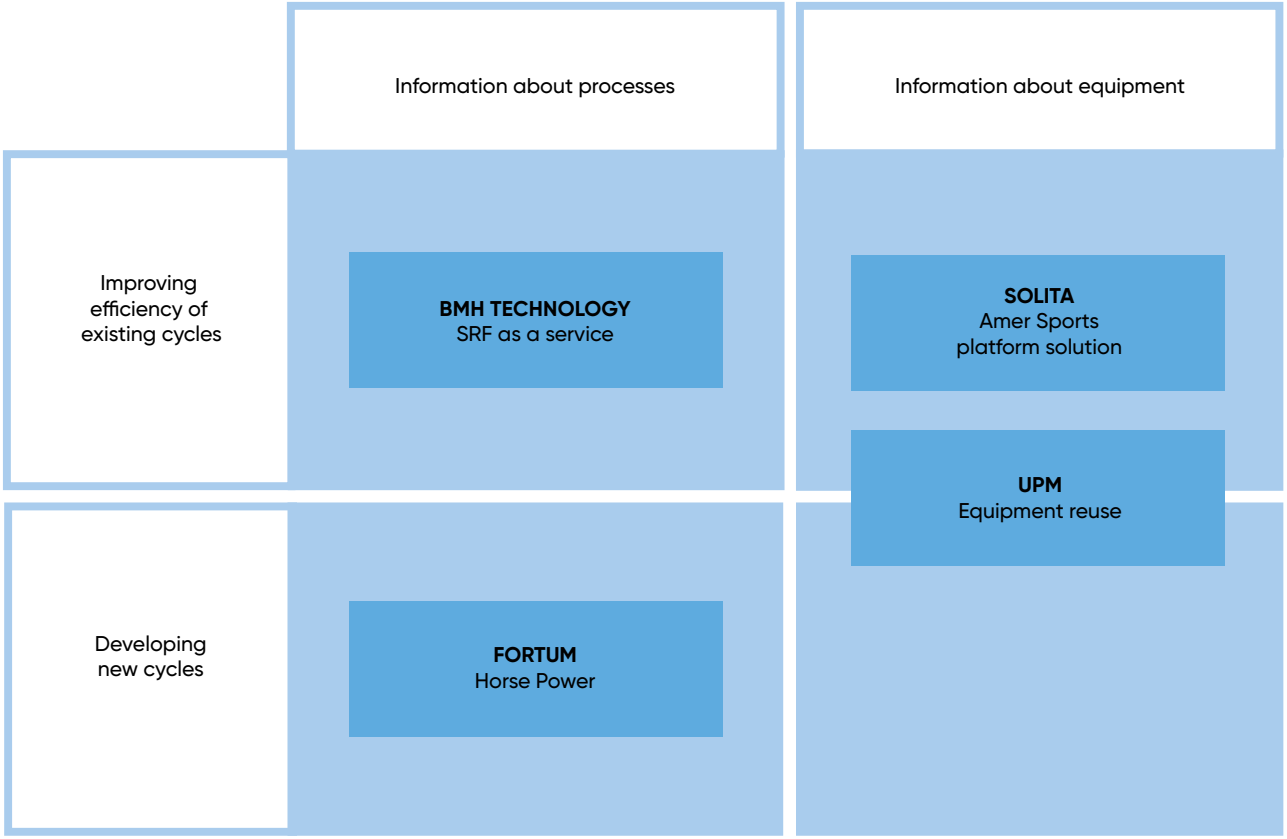


Figure 7
CATEGORIZATION OF CE SOLUTIONS.

3 A TOOLKIT FOR UNLOCKING CIRCULAR BUSINESS

The aim of this publication so far has been to advance the development of circular business by providing research-based information and inspiring examples of different types of circular business models. In particular, the examples have highlighted the role of information as an enabler for business and innovations. Now it is time for action! This chapter presents a toolkit for CE disruption. The tools presented are targeted toward managers and decision-makers to help on the road toward circular business.

As innovation develops into actions, the road toward circular business can be divided into a few main steps (see Figure 8). The tools introduced in this publication are targeted to help on this road. The first step is the ideation phase. This phase can be divided into sub-phases beginning with the identification of needs, possibilities, and requirements (external and internal drivers) and idea generation and assessment. The target of this phase is to set boundaries, seek possibilities for business, and create ideas for further analysis. Tools 1 and 2 are especially targeted to help in this phase.

1. **CE scenario building method.** This tool supports identifying CE opportunities and threats for current and future business.
2. **Circular business idea evaluation tool.** This tool helps in evaluating, comparing, and refining different circular business ideas.

The second step is the problem and research phase, in which the more concrete problem that the business is aiming to solve is defined. This phase also includes the research actions required for the solution to work. Tool 3, in particular, is targeted for research purposes, and tool 4 may help in defining the problem and in searching for possible solutions to this problem by paying extra attention to knowledge utilization. The third step is the solution phase, in which the focus is on solution development actions. The fourth step is all about business modeling, with a tighter focus on value creation actions, including, e.g., setting the value proposition; defining core customer segments, key actions, and stakeholders; cost structure; and revenue streams. Tool 5 can particularly help in the development of the core network required for business model establishment.

3. **Framework for assessing CE impacts for assets.** This tool is targeted toward helping decision-makers assess the CE impacts from their assets' perspectives when developing novel or assessing existing solutions.
4. **Roadmap for knowledge utilization.** This tool focuses on the information aspect of circular business by illustrating the process of transforming relevant data into information, knowledge, and, finally, wisdom to be used in decision-making.
5. **Value network mapping**. This tool helps in identifying, choosing, evaluating, and visualizing potential network partners needed in implementing the CE business concept.

The fifth and final step is the implementation of the solution, including market introduction and follow-up actions. Tool 6 is a detailed tool that targets business concept evaluation. It could be especially useful in the business model design and solution implementation phases. In addition, this tool could be used in earlier phases and could be helpful when paying attention to key questions to be considered when designing CE solutions.

Circular business concept evaluation tool. This tool is introduced to help in evaluating the potential of circular business. An extended version of Tool 2, it presents the key questions to be considered when developing CE initiatives.

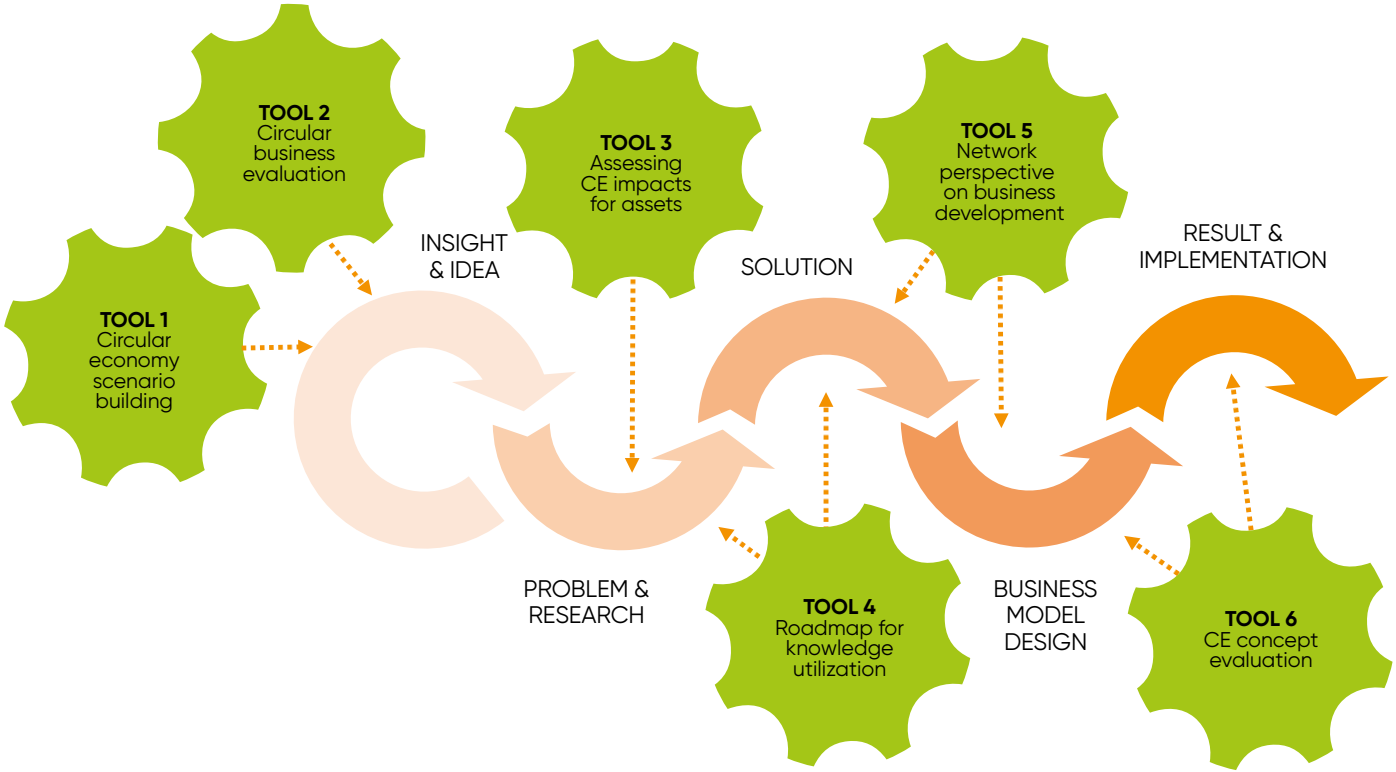


Figure 8
TOOLKIT TO HELP ON THE ROAD TOWARD CIRCULAR BUSINESS.

3.1 Tool 1: Building Circular Economy Scenarios

The target of the tool

CE may present either an opportunity or a threat for companies. Adopting CE principles affects companies' current and future competitiveness. The shift toward a more circular and sustainable economy is, however, a necessary course of action. To prepare for the shift, we argue that companies should systematically explore the alternative futures associated with their strategies and business. The future of CE can be explored using, e.g., morphological analysis, roadmaps, futures wheel methods, or scenario methods. All methods are useful for the systematic analysis of future business environments, CE solutions, and enablers and barriers of CE. The main challenges related to CE include the uncertain impacts of CE on companies, the complexity of solutions, and successful solutions that require a paradigm shift in many cases. These challenges can be addressed by scenario methods.

How the tool works

There are several methods for building scenarios. In this project, the following process was used :

1. defining issues that should be understood better,
2. identifying major stakeholders and actors,
3. identifying the main forces that shape the future,
4. identifying key trends that affect the issues of interest,
5. identifying key uncertainties from the list of future shaping forces and examining their interrelations,
6. selecting two key uncertainties and cross their outcomes in a matrix; adding outcomes of trends and other key uncertainties to the scenarios,
7. assessing the plausibility of scenarios and revise if necessary,
8. assessing the behavior of key stakeholders in the revised scenarios,
9. exploring the possibility of quantitative model, and
10. reassessing the uncertainty ranges of main variables.

Scenarios were built for, e.g., adopting CE solutions in the smart city context. The goal here was to analyze the role of information systems in CE solutions. An example of the scenario matrices is presented in Table 1. In this example, the most important variables were data ownership and business models.

Table 1 *EXAMPLE OF A SCENARIO MATRIX.*

	BUSINESS MODEL – SMALL CHANGE	BUSINESS MODEL – RADICAL CHANCE
Data ownership - Small change	• Closed data • Actor's own business models *Example:* *Business as usual in smart city business development*	• Closed data • Symbiotic business models in the smart city ecosystem follow CE principles *Example:* *Smart city ecosystems do not share their data outside their ecosystem but follow CE principles in their services and processes*
Data ownership - Radical change	• Open data • Actor's own business models *Example:* *Adopting principles from regulation-based OREDA activity in oil and gas industry in Norway (i.e., sharing relevant data openly inside the smart city ecosystem to enable new service opportunities)*	• Open data • Symbiotic business models in the smart city ecosystem follow CE principles *Example:* *Smart city ecosystems transparently share information outside their ecosystem and follow CE principles in their services and processes*

3.2 Tool 2: Circular Business Idea Evaluation

The target of the tool

CE is driven forward by certain factors that support the introduction of new business concepts. In the field, however, there also exist barriers that hinder innovation and business development. To build the best possible premises for the development of CE initiatives, it is important to build understanding about these drivers and barriers. This, in turn, helps to reduce the risk of ignoring relevant antecedent factors when considering the introduction of new business concepts. Therefore, there is a need for tools to evaluate CE business concepts, beginning with the ideation stage of development. The developed circular business idea evaluation tool aims to support the selection of promising business ideas that should be allocated more personnel resources. These ideas are selected first for idea enrichment and, after a second evaluation, for concept formulation.

How the tool works

The circular business idea evaluation tool provides a holistic perspective of a firm's internal and external business environments when developing business around CE.[1] The tool is targeted for circular business idea evaluation (see Figure 9). It consists of seven distinct categories, including different antecedent factors that affect the introduction of new CE business initiatives. The tool provides a checklist for evaluating business ideas from a CE perspective. It ensures that all relevant perspectives are considered when developing the idea into a concept.

1 The tool is developed based on the framework of barriers and drivers for circular economy, introduced in Tura, N. et al. (2018) Unlocking circular business: a framework of barriers and drivers

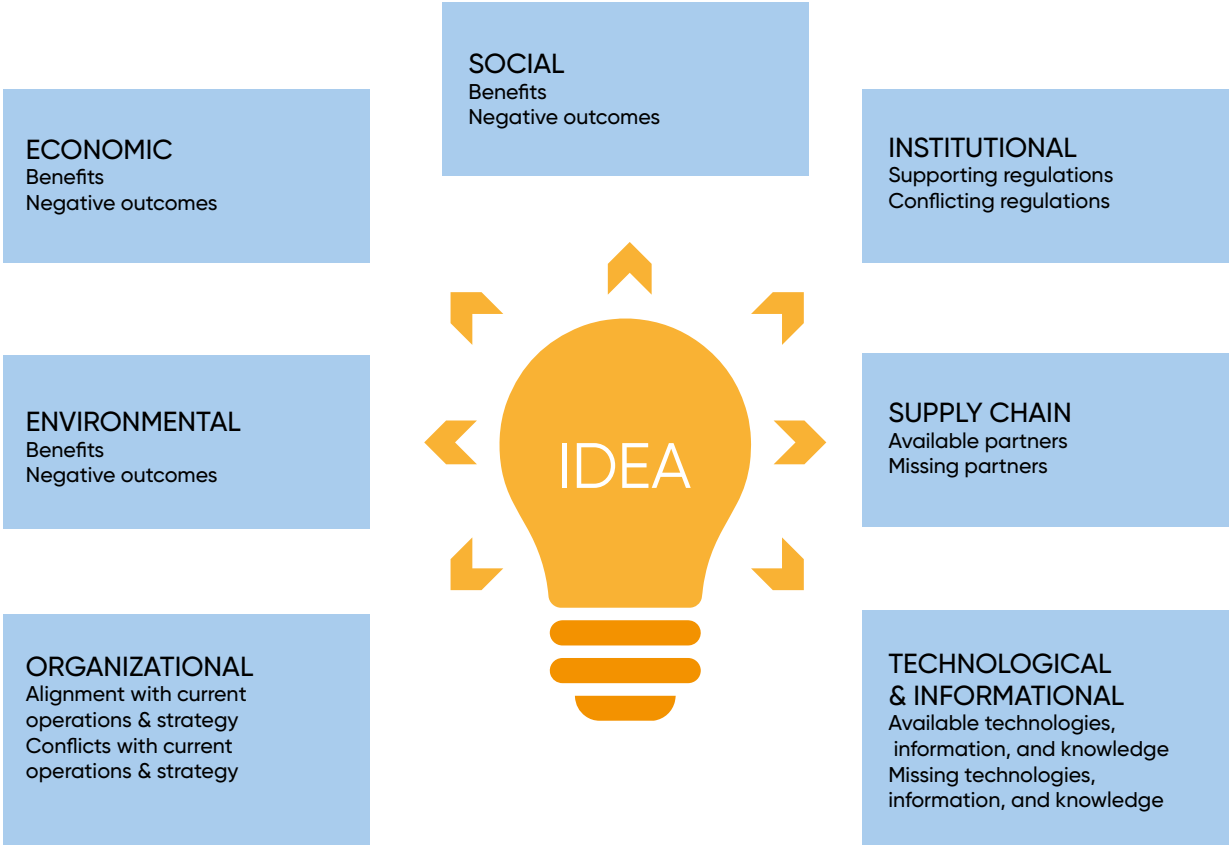


Figure 9
EVALUATION TOOL FOR NEW CE BUSINESS IDEAS.

3.3 Tool 3: Assessing CE Impacts for Assets

The target of the tool

CE solutions often require equipment and machinery (assets) that must be managed to ensure their reliable and safe operation. CE solutions might require new types of assets or for the old assets to be installed in new operating environments. Asset management plays a major role when CE solutions are implemented and targeted strategic objectives are pursued. CE and asset management goals are generally aligned, as both aim at optimizing resource value over solution life cycle. As the main difference, asset management decisions consider multiple decision criteria, including the economic perspective and risk. CE focuses on extending the resource use after the first life cycle and replacing non-renewable with renewable materials. From an asset management perspective, CE solutions may not always be viable. There is a need for tools to consider the effects of CE solutions on asset management, identify the strengths and weaknesses of CE solutions, and develop them from an asset management perspective.

How the tool works

Table 2 presents a framework that aims to highlight the opportunities and threats involved in CE solutions from the perspective of asset management[1]. These opportunities and threats can be viewed through asset management fundamentals[2]: the **value** provided to the organization, the **alignment** of plans and activities, **leadership** and **culture** that ensure that employees in the organization have clear roles and responsibilities and are competent and empowered, and **assurance** that assets fulfill their purpose. CE solutions are compared with existing linear solutions. The evaluation framework focuses on transitioning to a CE solution from the perspective of the assets required. Examples of CE asset management opportunities include extending the lifetimes and increasing the efficiency of assets, facilitating the recycling or reuse of components and equipment, offering new purposes for the old equipment, and cost savings. CE solutions increase the need for usage history data. Consequently, additional opportunities may result from more efficient decision-making and from better availability and quality of information. Threats related to asset management include the complexity of the supply chain and information systems, management of new value elements, and the assurance of quality in the new production ecosystem. In general, companies may require new partners to provide CE solutions, which may present either an opportunity or a threat.

1 The tool is developed based on the framework introduced in Hanski et al., 2016 Circular economy models: Opportunities and threats for asset management.
2 ISO (2014) ISO 55000-2 Asset Management standards.

Table 2 *FRAMEWORK FOR ASSESSING CE IMPACTS FOR ASSETS*

Asset management fundamental	ENSURE THE REALIZATION OF OPPORTUNITIES AND AVOID THE THREATS
Value	• Define the **value** elements that are provided to the organization and its stakeholders over the life cycle of the solution.
Alignment	• Describe the impact of the solution for planning and decision-making processes. • Describe the impact of the solution for the **alignment** of organizational objectives, plans, activities, processes, and decisions.
Leadership	• Describe the impact of the solution for **leadership and workplace culture** that ensure that employees in the organization have clear roles and responsibilities and are competent and empowered.
Assurance	• Describe the impact of the solution for the **assurance** that assets fulfill their required purpose. • Describe the impact of the solution for the processes of connecting purposes and the performance of assets for organizational objectives. • Describe the impact of the solutions for monitoring and continual improvement.

3.4 Tool 4: Roadmap for Knowledge Utilization

The target of the tool

Knowledge utilization is a central element in identifying new business ideas and developing these ideas into business concepts. The development of innovations for CE requires the use of relevant sustainability knowledge (i.e., creating market value by combining pieces of environmental, organizational, and social information). The roadmap for knowledge utilization tool aims to support the process of transforming data into information, to knowledge, and, finally, to wisdom used as the basis of circular business initiatives (see Figure 10).

How the tool works

The roadmap tool provides a holistic perspective on the knowledge utilization process that supports innovation development for CE[1]. The presented tool is targeted for decision-makers to help them understand the transformation process—from data to the managerially usable stock of knowledge and, finally, to wisdom. It highlights the five main steps to be followed, each involving specified tasks and questions to be considered (see Figure 11).

1 The tool is developed based on the ideas of Mohamed et al. (2009) An empirical assessment of knowledge management criticality for sustainable development and Tura et al. (2018) Innovations for sustainability: Challenges of utilizing sustainability-related knowledge.

WHY?

Specify the sustainability or CE challenge and/or goal under consideration. What are the internal motives? What are the external requirements?

WHERE?

Specify the sources for data and measurement. Collect the data and transform it into information. Analyze the information into knowledge.

WHAT IS THE VALUE?

Determine the knowledge gap: What is useful from the perspective of the determined goal/challenge? What knowledge is relevant from CE development perspectives? Determine the relevancy of the data: ranking and prioritization based on CE business development objectives.

WHAT IS MISSING?

Create inferences from validated knowledge: Is knowledge missing? Identify new/supporting knowledge. Combine knowledge sources inside the organization and across organizational boundaries.

HOW TO USE?

Determine strategies to communicate the knowledge to relevant stakeholders. Identify the real value proposition: how knowledge is mobilized and deployed to add circular value.

Figure 10
THE PROCESS OF KNOWLEDGE UTILIZATION FROM NEED TO WISDOM.

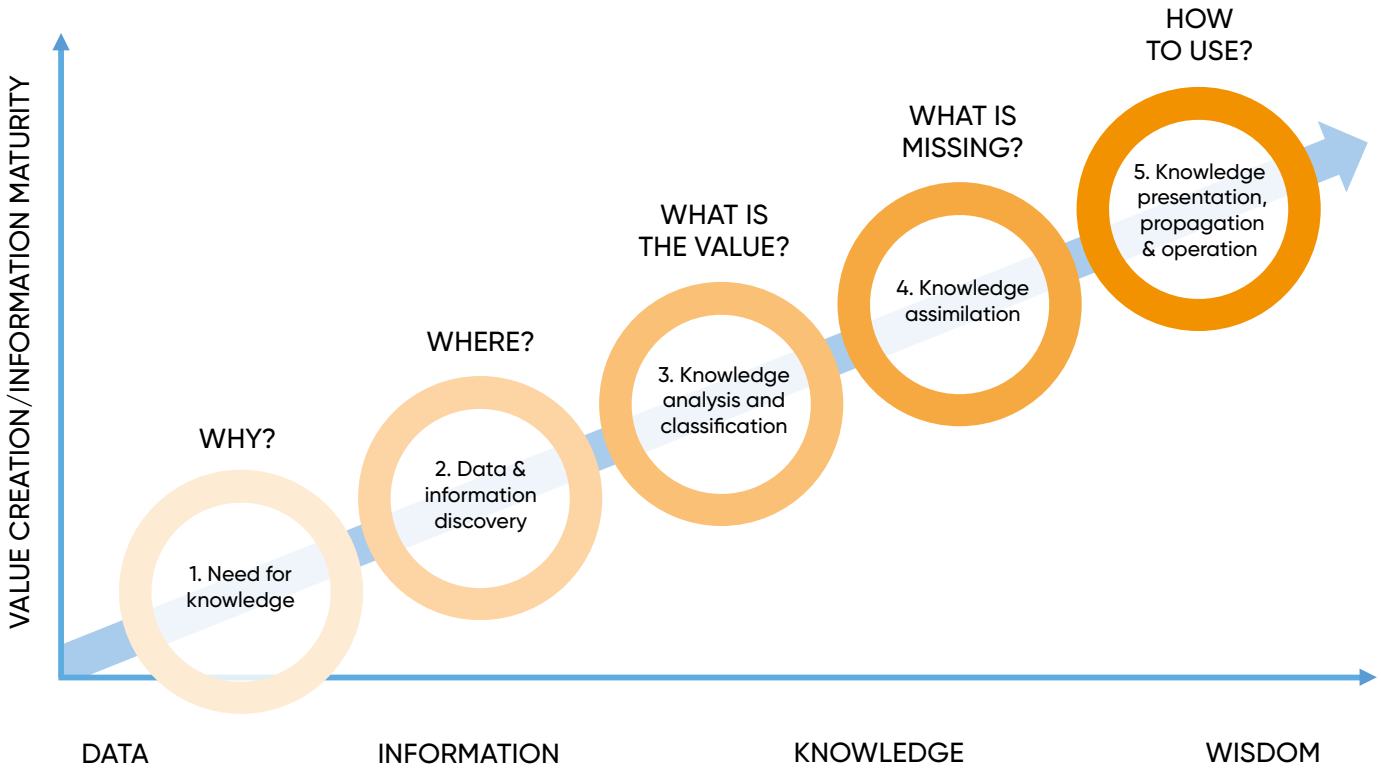


Figure 11
ROADMAP FOR KNOWLEDGE UTILIZATION.

3.5 Tool 5: Network Perspective on Business Development

The target of the tool

Collaboration is necessary for creating micro-level circular systems. It is important, therefore, to understand which stakeholders are operating in your system with you and their motivations for collaboration[1]. When evaluating potential network partners, the entire network must be identified and conceptualized to determine the most relevant actors. Traditionally, so-called network picturing offers the potential to see beyond the most obvious and traditionally closest actors[2]. Traditional network concepts view the whole network from an individual actor's perspective[3]. The basic assumption often conceives of one dominant network actor and one firm that manages the entire network.

However, the fundamental managerial issue at play in forming and renewing business networks—including CE networks—is how to collaborate rather than considering just one firm's perspective[4]. If CE business opportunities are to be created, the entire network needs to be described to understand the whole value creation logic and potential new ways of doing business. Network picturing also makes it possible to identify the information and material flows between actors and, especially, to recognize where these flows should exist. Thus, our tool not only examines the focal firm's perspective on CE but the whole network's relation to certain CE business opportunities.

How the tool works

The tool comprises a step-by-step approach to identifying, evaluating, choosing, and visualizing a possible network that supports the focal CE business model innovation. This model is presented in Figure 12, and the steps are subsequently described in detail. We see this process as iterative, meaning that previous steps can be revisited if new ideas develop during the process.

BACKGROUND: This phase relates to the previous tool(s) presented in this report (such as tool 2). The idea is that a potential CE business model/concept has already been conceptualized. Once the basic idea has been determined based on a careful evaluation process, the focus can be moved to evaluating the necessary network in implementing the concept.

1 Kraaijenhagen et al. (2016) Circular Business: Collaborate & Circulate.
2 Håkansson and Ford (2002) Developing relationships in business networks.
3 Leek and Mason (2009) Network pictures: Building an holistic representation of a dyadic business-to-business relationship.
Håkansson and Snehota (1995) Developing relationships in business networks.
4 Valkokari and Valkokari (2014) How SMEs Can Manage Their Networks–Lessons Learnt from Communication in Animal Swarm

STEP 1: Step 1 is concerned with identifying potential and required business partners for implementing the concept. The whole value network must be considered (i.e., identifying the partners required not only in delivering the products and services but also in returning the usable materials in the cycle—the so-called end-of-life partners). Stakeholders who are not directly linked to the business concept but who may indirectly affect the actions of the network partners must also be considered. These could be, for example, governments and policymakers that regulate the business environment.

STEP 2: After potential partners are identified, they must be evaluated and, ultimately, chosen to implement the business concept. The matrix below (Table 3) could help in evaluating partners. The idea of the matrix is not just to consider the perspective of the focal firm (what the partners could offer to the focal firm) but to consider how the entire network can benefit from its contributors. Different partners can be added—as many as needed. The aim is to identify the resources and information the partners can offer to each other by looking at both intersections (focal firm-customer and customer-focal firm intersections) in the table. Steps 1 and 2 overlap to an extent, meaning that as partners are evaluated, other partners may be considered as potential members of the network.

STEP 3: Finally, in step 3, after the required partners have been identified and chosen, the network can be visualized. Visualization can help to validate previous work, and new business ideas and potential new partners can potentially arise during the process. Visualization often helps in recognizing where different material and information flows[5] exist and where they do not exist. In practice, draw all the relevant actors and their positions in the network (as done in the case examples in section 2 in this report) and identify the most important material and information flows between the actors. The needed CE business model network described and visualized (as in the case examples of this report in sections 2.1–2.4) should result.

5 For more information about identifying and visualizing CE information flows, see Ståhle (2017) and Suomi (2018).

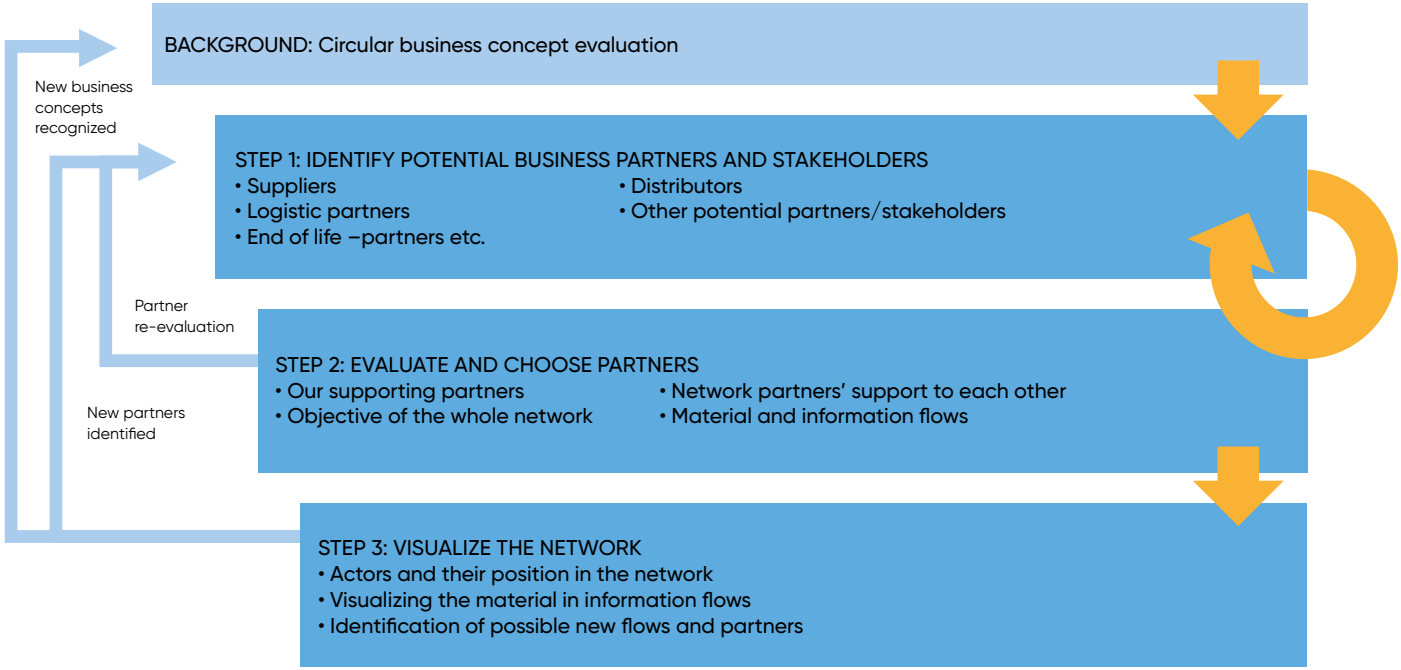


Figure 12
STEP-BY-STEP TOOL FOR EVALUATING POTENTIAL CE NETWORK.

Table 3 *MATRIX FOR EVALUATING BUSINESS PARTNERS*

	FOCAL FIRM (CAN OFFER)	CUSTOMER/ CLIENT	SUPPLIER	DISTRIBUTOR	PARTNER N
FOCAL FIRM (CAN BE OFFERED TO)		What resources and information can **customer** offer to **focal firm**?	What resources and information can **supplier** offer to **focal firm**?	What resources and information can **distributor** offer to **focal firm**?	What resources and information can **any other** partner offer to **focal firm**?
CUSTOMER/ CLIENT	What resources and information can **focal firm** offer to **customer**?		What resources and information can **supplier** offer to **customer**?	What resources and information can **distributor** offer to **customer**?	What resources and information can **any other partner** offer to customer?
SUPPLIER	What resources and information can **focal firm** offer to **supplier**?	What resources and information can **customer** offer to **supplier**?		What resources and information can **distributor** offer to **supplier**?	What resources and information can **any other** partner offer to **supplier**?
DISTRIBUTOR	What resources and information can **focal firm** offer to **distributor**?	What resources and information can **customer** offer to **distributor**?	What resources and information can **supplier** offer to **distributor**?		What resources and information can **any other partner** offer to **distributor**?
PARTNER N	What resources and information can **focal firm** offer to **any other partner**?	What resources and information can **customer** offer to **any other partner**?	What resources and information can **supplier** offer to **any other partner**?	What resources and information can **distributor** offer to **any other partner**?	

3.6 Tool 6: CE Concept Evaluation

The idea/target of the tool

The CE concept evaluation tool is a continuation of the circular business idea evaluation tool (tool 2).[1] The checklist (table 4) for this tool is more comprehensive, as it aims to support go/no-go/hold decisions when CE business concept options are compared. The comparison results in suggestions for further improving certain categories of evaluated business concepts. The tool also aims to support selecting the most suitable concepts for new business development.

1 The tool is developed based on the framework of barriers and drivers for circular economy, introduced in Tura, N. et al. (2018) Unlocking circular business: a framework of barriers and drivers.

How the tool works

The tool consists of seven distinct categories with a set of key and specifying questions. The goal is to determine how well the properties of the concept cover the requirements set by the questions. There are two options for this. First, for each question, the concepts are given a score (e.g., -2...2). The results of concept scoring are compared to determine their key weaknesses and strengths.

To reach comparable results when using the CE concept evaluation tool, two factors must be considered. First, a baseline has to be formed for the evaluation. This is often achieved by selecting a reference item (for example, a product or service). Second, evaluation criteria for different scoring values must be defined either qualitatively and/or quantitatively. For instance, a score of 2 could be defined as "major improvement compared with baseline" or "90% less CO_2 emission." The tool should always be tailored to the organizational objectives. Figure 13 shows an example of an evaluation based on the categories determined in Table 4.

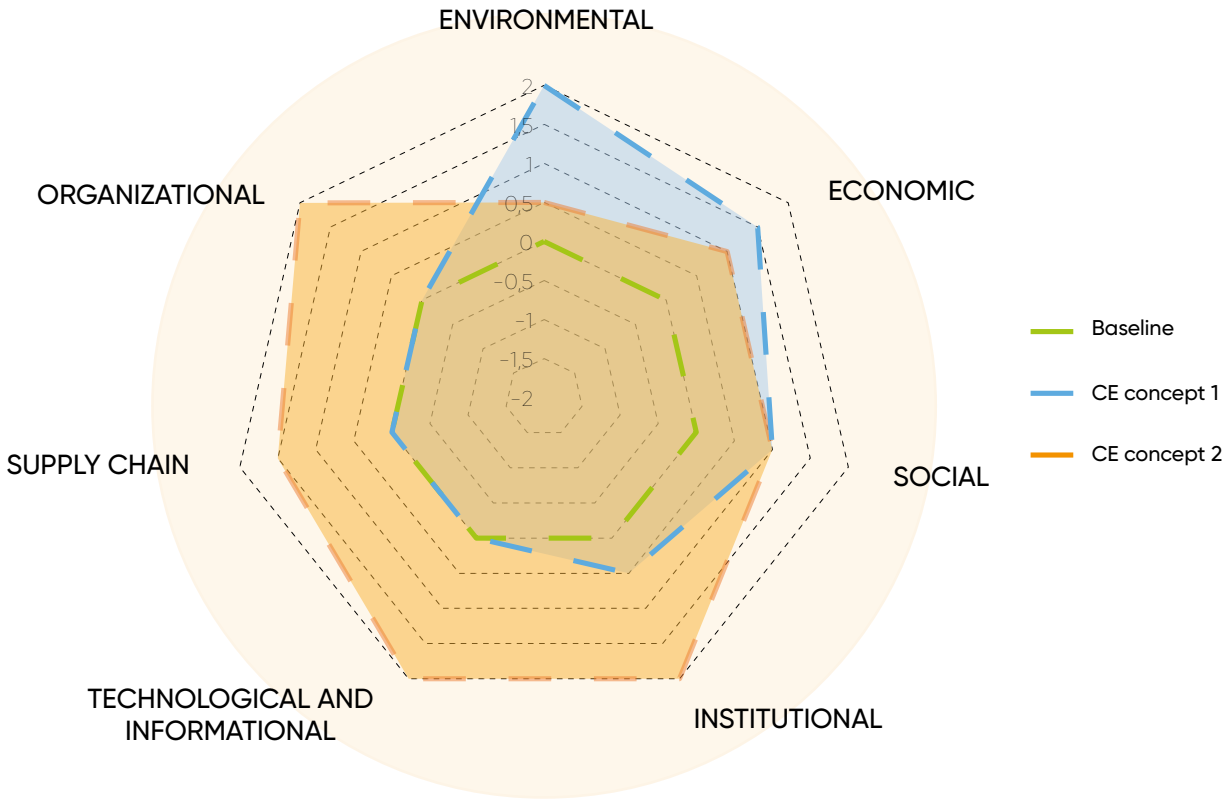


Figure 13
EXAMPLE OF CE CONCEPT EVALUATION.

Table 4 *CIRCULAR ECONOMY BUSINESS CONCEPT EVALUATION TOOL*

CATEGORY		KEY QUESTIONS	SPECIFYING QUESTIONS
Environmental	Analysis of the business's estimated impact on the environment	What are the **environmental benefits** of the CE initiative? Are there possible negative **environmental impacts**?	Does the initiative consider resource constraints? Does the initiative reduce or help in preventing environmental impacts?
Economic	Analysis of the possibilities for gaining profits and financial uncertainty	What are the **economic benefits** of the CE initiative? Are there possible **negative economic outcomes**? What **tools and methods are required** to measure (long-term) benefits of the CE initiative?	Does the initiative improve cost-efficiency? How? What are the revenue streams? Are there new sources for revenue and profit? What is the cost structure of the initiative? How uncertain is the financing? What are the firm's financial capabilities? Are external financing and support available?
Social	Analysis of the business's estimated impact on society	What **social problem** does the CE initiative aim to resolve? Is there a **demand** for the CE initiative? What is the **development state of the industry**? How does the CE initiative **increase regional/national vitality**?	What is the awareness rate of the targeted market of sustainable development requirements and CE? How crucial is the problem that the initiative targets? Is there a specific customer need that the CE initiative aims to address? What are the substitute solutions? Does the CE initiative create new jobs?
Institutional	Analysis of the existing institutional regulations, requirements, support	Do current/upcoming **regulations and standards** affect the development of the CE initiative? What are the **institutional premises** in the different countries/areas that the CE initiative targets?	Are supportive funds, taxation, and subsidies available? Are there regulations and standards conflicting with the development of the CE initiative? How familiar is the theme of the CE initiative for political decision-makers?
Technological & Informational	Analysis of the available & developing (information) technologies and skills	How does the CE initiative improve existing operations? What are the **(information) technological resources and competences** available? Are there **emerging (information) technologies** supporting the development of the CE initiative?	Are required information and knowledge lacking? Are required technologies and technical skills lacking?

CATEGORY		KEY QUESTIONS	SPECIFYING QUESTIONS
Supply chain	Analysis of the network dependency & opportunities	Who are the **key partners** in the CE initiative? Are there clear **communication and network management** practices? How does the **industry support** the development of CE business?	Are resources available? Are new partners needed? How multidisciplinary is the network? What are the practices that support open collaboration, resource sharing, and communication?
Organizational	Analysis of the organizational operations, capabilities, resources, and culture	How is CE considered in company s**trategy, goals, and values**? How is the CE initiative in line with the company's **current operations**? Does the CE initiative include **non-monetary organizational benefits**? What is the current CE **skill/capability level** inside the organization? What is the **risk tolerance** of the organization? Is management committed to CE business development?	Are there any incompatible operations and development targets with the CE initiative? How does the existing business culture support CE ideology? Is there a need for the development of CE knowledge and skills? Are educational sources available? Is the organization capable of change? What is the organization's degree of internal cooperation?

4 CONCLUSIONS

Research and practice regarding innovation and CE business opportunities are developing quickly. Our findings concern some companies that have implemented, perhaps unconsciously, practices that follow CE principles—forerunners that highlight sustainability and, thus, CE in their strategies. However, as we have discovered through this research project, CE business concepts are far from being fully executed, and there is still a relatively limited amount of practical knowledge about how manufacturers, service providers, consumers, and other stakeholders need to act to realize the full potential of CE business. In concluding, we first present an outline of the ongoing shift toward CE business and then suggest acknowledged research topics to support companies' transitions toward CE business.

4.1 Concluding Discussion

Information plays a crucial role in the development of CE business models. In general, these models are dependent on information about the characteristics, conditions, locations, and availability of assets. Although the information items are quite generic in all CE business cases, each company has different requirements concerning data and information when executing business following CE principles. Different types of information are required depending on the business case, such as information about condition of assets, composition of material flows, relevant partners and stakeholders, and the technologies relevant for processing information flows. Therefore, in addition to the technical and biological cycles, business case-specific information management could be regarded as a third important cycle in CE.

Digital technology is often considered an enabling technology that can monitor valuable smart solutions and materials much more economically than before. Many companies currently use several existing information systems. These old systems could potentially prevent moving toward CE business, as their rather unwieldy data item structures are not designed to support the execution of circular business. Investments in replacing old information systems could thus form a high barrier to CE business implementation. Ideally, new digital technology solutions should be easily connectable to enrich the data that old information systems contain.

Implementation of CE business frequently requires a new kind of cooperation in the value network or even the creation of a new business ecosystem. To realize the value of CE business opportunities, the entire network needs to be described to better understand the whole value creation logic and potential new ways of doing CE business. The description of the new CE value network, or ecosystem, should also support the governance of the actors involved in the network. This is merely one important aspect, as reaching new sustainability targets is not achieved through the activities of just one actor.

The D2W project had three key approaches to circular business: 1) data and wisdom, 2) relationships and networks, and 3) innovation and business models (Figure 14). The first approach aimed to identify the data and information in company networks and convert it into wisdom and circular business opportunities. Tools 1, 3, and 4, in particular, were related to this approach. The second approach aimed at leveraging relationships and networks for circular business. Tool 5 focused on this approach. The third approach focused on revolutionizing circular value formation through disruptive business models and innovation. Tools 2 and 6 focused on this approach. The three approaches intersect in the method developed for modeling CE solutions and the case studies presented in chapter 2. This method combined the information streams, networks, and relationship views with the business and value concepts for the actors involved in the network.

4.2 Future Research

The D2W research project focused on the importance of information management when creating and executing CE business in a multidisciplinary multi-company setting. Despite this plentiful context for research and learning, it is obvious that many areas that facilitate CE business have not yet been covered adequately.

Examples of new themes for the following steps of research include:

- Key performance indicators of CE and sustainable development
- Governance of CE business ecosystems
- New AI (IT) technologies, opportunities, and requirements in CE implementation

Key performance indicators of CE and sustainable development will facilitate the extension of carbon footprint reduction to reducing resource and energy consumption. It will form a baseline for monitoring the resource handprint of CE solutions and support the determination of the overall impacts of CE solutions.

The governance of CE business ecosystems will focus on challenges related to the creation of symbiotic business relationships in industrial ecosystems. This requires new collaboration, communication, and coordination approaches within complex networks of interdependent but independent actors/stakeholders. It will especially emphasize the movement from an individual actor perspective toward the network/system/society level aspects of CE.

New AI (IT) technologies, opportunities, and requirements in CE implementation will concentrate on studying the impacts of new AI (IT) technologies (e.g., bargain chains/smart deals) for CE business. It will also create special tools for the CE innovation process to support the implementation of CE solutions, monitoring, and concept maturity assessment and will clarify issues related to the responsibilities of these new systems.

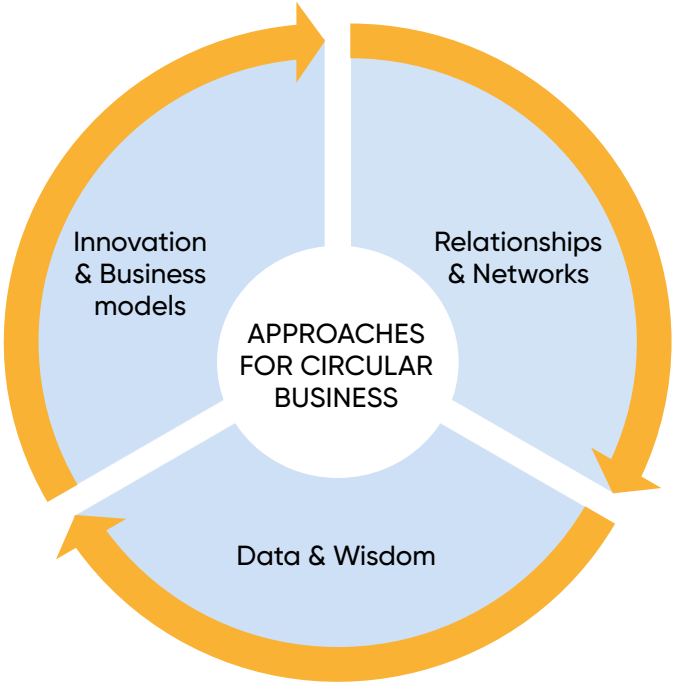


Figure 14
D2W PROJECT'S KEY APPROACHES TO CIRCULAR BUSINESS.

DATA TO WISDOM PROJECT PUBLICATIONS

- Ahola, T., Ståhle, M., and Martinsuo, M. (2018). Agency relationships in global project business. Proceedings of the EURAM European Academy of Management conference, 19–22 June 2018, Reykjavik, Iceland.
- Ahola, T., Ståhle, M., and Martinsuo, M. (2017). Using sales agents in project marketing. Proceedings of the IRNOP International Research Network on Organizing by Projects conference, 11–14 June 2017, Boston, USA.
- Hanski, J., (2017). Towards asset management framework for circular economy models. Proceedings of International Symposium on Design Science in Innovation and Engineering Research (DSIER 2017), 6–7 September 2017, Lappeenranta, Finland.
- Hanski, J., and Valkokari, P. (2018). Impact of circular economy on asset management–lifecycle management perspective. Proceedings of World Congress on Engineering Asset Management (WCEAM2018), 24–26 September 2018, Stavanger, Norway.
- Hanski, J., Valkokari, P., Kortelainen, H., and Ahonen, T. (2016). Circular economy models: Opportunities and threats for asset management. Proceedings of Maintenance Performance Measurement and Management Conference (MPMM2016), 28 November 2016, Luleå University of Technology, Sweden.
- Hanski, J., Valkokari, P., and Uusitalo, T. (2017). Kiertotalous korostaa kunnossapidon merkitystä. Promaint, 2/2017, 14–16.
- Järvi, H., and Tura, N. (2017). Pioneering sustainability-oriented business models in hotel industry. Proceedings of ISPIM Innovation summit, 10–13 December, Melbourne, Australia.
- Martinsuo, M., and Killen, C. (2017). Decision making on strategic value at the front end of system delivery projects. Paper presented at EUROMA European Operations Management Association Conference, 3–5 July 2017, Edinburgh, U.K.
- Nasiri, M., Tura, N., and Ojanen, V. (2017). Developing Disruptive Innovations for Sustainability: A Review on Impact of Internet of Things (IOT). Proceedings of PICMET '17: Technology Management for Interconnected World, 9–13 July, Portland, Oregon, USA.
- Piiparinen, S. (2017). Developing Circular Business in Urban Ecosystems. Master's Thesis. Lappeenranta University of Technology, Industrial engineering and Management. Available: http://urn.fi/URN:NBN:fi-fe201708077878
- Rana, P., Short, S. W., Evans, S., Granados, M. H., and Valkokari, K. (2016). Toolset for Sustainable Business Modelling. In: Value Networks in Manufacturing: Sustainability and Performance Excellence. Springer, pp. 123–153.
- Ståhle, M., Ahola, T., and Martinsuo, M. (2019). Cross-functional integration for managing customer information flows in a project-based firm. International Journal of Project Management, 37(1), 145–160.
- Ståhle, M., Ahola, T., and Martinsuo, M. (2017). Cross-functional integration for managing customer information flows in a project-based firm. Proceedings of the ANZAM Australian and New Zealand Academy of Management conference, 6–8 December 2017, Melbourne, Australia.

- Ståhle, M. (2017). Circular economy customer information in the business network of a project-based firm. Master's thesis (in Finnish), Tampere University of Technology. Available: http://urn.fi/URN:NBN:fi:tty-201705191430
- Suomi, T. (2018). Information flows in the project networks of circular economy solution deliveries. Master's thesis (in Finnish), Tampere University of Technology.
- Tura, N. (2018). Drivers and barriers for innovating sustainable energy transition in Chile, Proceedings of ISPIM Connects Fukuoka—Building on Innovation Tradition, Fukuoka, Japan, on 2–5 December 2018.
- Tura, N. (2018). Value creation for sustainability-oriented innovations: challenges and supporting methods, Acta Universitatis Lappeenrantaensis 799, Available: http://urn.fi/URN:ISBN:978-952-335-236-0
- Tura, N., Hanski, J., Ahola, T., Ståhle, M., Piiparinen, S., and Valkokari, P. (2018) . Unlocking circular business: a framework of barriers and drivers. Journal of Cleaner Production. https://www.sciencedirect.com/science/article/pii/S0959652618336059
- Tura, N., Keränen, J., and Patala, S. (2018). The darker side of sustainability: Tensions from sustainable business practices in business networks. Industrial Marketing Management, forthcoming. https://doi.org/10.1016/j.indmarman.2018.09.002
- Tura, N., Kutvonen, A., and Piiparinen, S. (2017). Continuing education requirements for supporting sustainability-oriented innovations. Proceedings of the XXVIII International Society for professional Innovation Management (ISPIM) conference, Vienna, Austria, 18–21 June 2017.
- Tura, N., Mortimer, G., and Kutvonen, A. (2018). Exploring the pitfalls of systemic innovations for sustainability. In: Innovation for Sustainability—Business Transformations Towards a Better World. Edited by Bocken, N., Ritala, P., Albareda, L., and Verburg, R., Palgrave Macmillan, Palgrave Studies in Sustainable Business (in Association with Future Earth), forthcoming.
- Tura, N., and Ojanen, V. (2018). Drivers and barriers for innovating sustainable energy transition: a case study of Chile. Proceedings of ISPIM connects FUKUOKA conference—Building on innovation tradition, Japan, 2–5 December 2018.
- Tura, N., Ojanen V., and Hanski J. (2018). Innovations for sustainability: Challenges of utilising sustainability-related knowledge. International Journal of Innovation and Sustainable Development, forthcoming. DOI: 10.1504/IJISD.2017.10012544.
- Tura, N., Ojanen, V., Paloviita, T., and Piiparinen, S. (2018). Knowledge-based collaboration in advancing sustainable urban energy ecosystems, Proceedings of IEEM Conference 2018, 16–19 December, Bangkok, Thailand.
- Valkokari, P., Hanski, J., and Ahonen, T. (2017). Impact of maintenance on circular economy. In: Aaltonen, J., Virkkunen, R., Koskinen, K. T., and Kuivanen, R. (Eds.). Proceedings of the 2nd Annual SMACC Research Seminar 2017, Tampere University of Technology, pp. 20–23.

REFERENCES

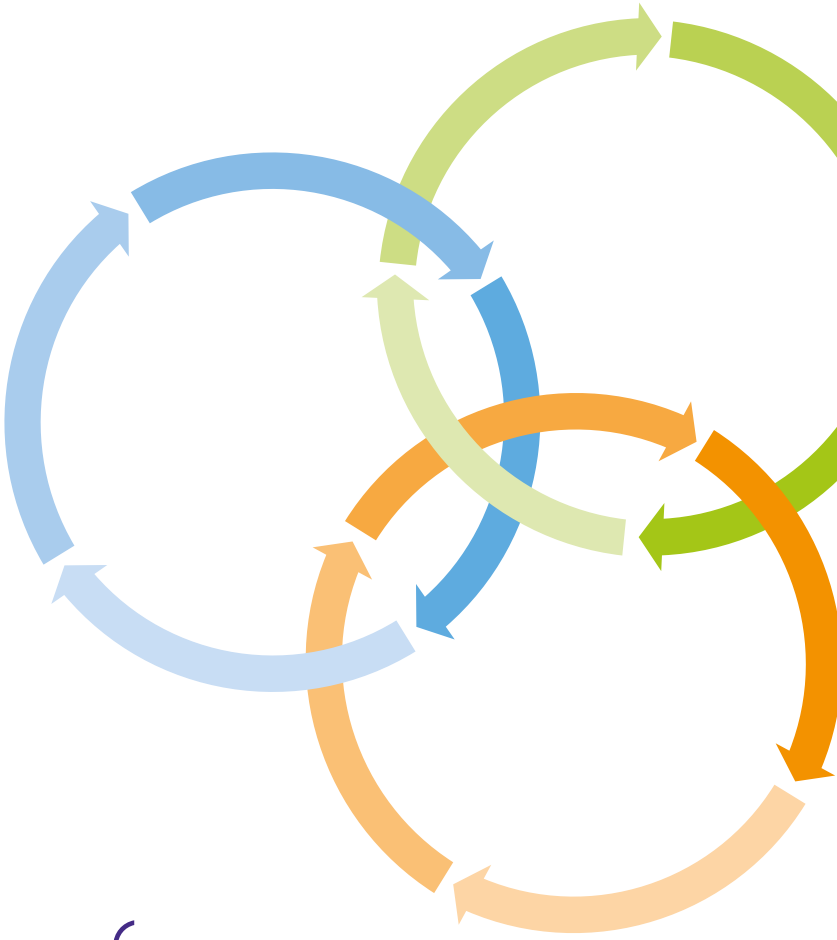
- Ackoff, R. (1989). From data to wisdom. Journal of Applied Systems Analysis, 16(1), 3–9.
- Bocken, N.M.P., De Pauwc, I., Bakkera, C., and Van Der Grintenc, B. (2016). Product design and business model strategies for a circular economy. Journal of Industrial and Production Engineering. 33(5), 308–320.
- Ek (2016). Take a leap into circular economy. Confederation of Finnish industries Ek, Helsinki.
- Ellen MacArthur Foundation (2013). Towards the Circular Economy: Economic and business rationale for accelerated transition (1). Cowes. Report. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf
- EMF (2016). Ellen MacArthur Foundation 2016. Intelligent assets: unlocking the circular economy potential. Available at: http://www.ellenmacarthurfoundation.org/publications/intelligent-assets.
- European Parliament (2018). Resource efficiency and circular economy. Fact Sheets on the European Union - 2018.
- Ghisellini, P., Cialani, C., and Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production, 114, 11–32.
- Håkansson, H., and Ford, D. (2002). How should companies interact in business networks?. Journal of business research, 55(2), 133–139.
- Håkansson, H. and Snehota, I. (1995). Developing Relationships in Business Networks. Routledge London.
- ISO (2014). ISO 55000-2 Asset Management standards.
- Kraaijenhagen, C., van Oppen, C., and Bocken, N.M.B. (2016). Circular Business: Collaborate & Circulate. Amersfoort, The Netherlands.
- Kunttu, S., Ahonen, T., Kortelainen, H., and Jantunen, E. (2016). Data to Decision—Knowledge-Intensive Services for Asset Owners. Proceedings of EuroMaintenance 2016, 30 May–1 June 2016, Athens, Greece, 75–83.
- Lacy, P., and Rutqvist, J. (2015). Waste to Wealth: The Circular Economy Advantage. Palgrave Macmillan UK.
- Leek, S., and Mason, K. (2009). Network pictures: Building an holistic representation of a dyadic business-to-business relationship. Industrial Marketing Management, 38(6), 599–607.
- Lieder, M., and Rashid, A. (2016). Towards circular economy implementation: A comprehensive review in context of manufacturing industry, Journal of Cleaner Production, 115, 36-51.
- McCarthy, A., Dellink, R., and Bibas, R. (2018). The Macroeconomics of the Circular Economy Transition: A Critical Review of Modelling Approaches, OECD Environment Working Papers , No. 130, OECD Publishing, Paris. Available at: http://dx.doi.org/10.1787/af983f9a-en
- Mohamed, M., Stankosky, M., and Mohamed, M. (2009). An empirical assessment of knowledge management criticality for sustainable development, Journal of Knowledge Management, 13(5), 271–286.

- Murray, A., Skene, K., and Haynes, K. (2015). The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context. Journal of Business Ethics, 140(3), 369–380.
- Schoemaker, P. J., and Mavaddat, V. M. (2000). Scenario planning for disruptive technologies. Wharton on managing emerging technologies, 206–241.
- Sitra (2017). The most interesting companies in the circular economy in Finland. Available at: https://www.sitra.fi/en/projects/interesting-companies-circular-economy-finland/.
- Sitra (2018). The circular economy - a powerful force for climate mitigation. 176 p. Available at: https://media.sitra.fi/2018/05/04145239/material-economics-circular-economy.pdf
- Valkokari, K., and Valkokari, P. (2014). How SMEs Can Manage Their Networks–Lessons Learnt from Communication in Animal Swarm. Journal of Inspiration Economy, 1(1), 111–128.

ADVANCING CIRCULAR BUSINESS

In this world of scarce resources, circular economy (CE) has been identified as an important means for increasing resource efficiency and reducing the use of natural resources. However, what does implementing circular business and operational models mean for companies' business execution, mindsets, and competitive edges?

This publication presents the practical case studies of several different CE business implementations. The focus on this exploration was to identify the role of information management in successful CE business execution.



VTT BUSINESS FINLAND LUT University Tampere University